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Properties of Steel at High Temperatures

By R. Willows, B.Sc. and Professor F. C. Thompson.

Effect of Prolonged Stress upon the Mechanical Properties of Two Spheroidised Steels at Elevated Temperatures.

ALTHOUGH an enormous amount of work has been done on the determination of the mechanical properties of steel at high temperatures, little or nothing has been attempted in the direction of measuring the effect of prolonged stressing at high temperatures on those properties after the material has again been allowed to cool down. Indeed, almost the sole test so carried out appears to be represented by the measurement by Rosenhain and Hanson[1] of a comparative hardness figure on a 0·11% carbon steel, which had been stressed at a temperature of 300° C. for five years.

The matter is, however, one of more than passing interest to the engineering profession, and is of vital concern to, amongst others, the boiler-maker and turbine-builder. The question as to whether steels are permanently impaired by such treatment as a boiler or turbine receives is clearly an important one, and many very curious facts are on record as a matter of fairly common knowledge. As an example of such may be mentioned a bolt from a turbine casing which, when the machine was dismantled, was found to be "as brittle as a carrot."

It is known generally that at some elevated temperature steels pass into the "blue-brittle" zone in which plastic deformation leads to a typically brittle kind of failure. There is still, however, some uncertainty as to whether this brittleness is merely temporary, and disappears when the steel is again cooled down, or whether it leaves behind some permanent deterioration.

In the hope that some light might be thrown on these and kindred subjects, the present work was undertaken.

The period for which the tests were carried out was five months only, and the steel wires used, as a result of the annealings which they had received below the carbon change-point in the process of drawing, were entirely spheroidised. The whole of the carbon, that is to say, was present in the form of globules of free carbide, and not, as would normally be the case, in areas of pearlite. What effect, if any, this fact has had upon the results it is impossible to say.

Experimental.

A general view of the apparatus used is shown in Fig. 1.

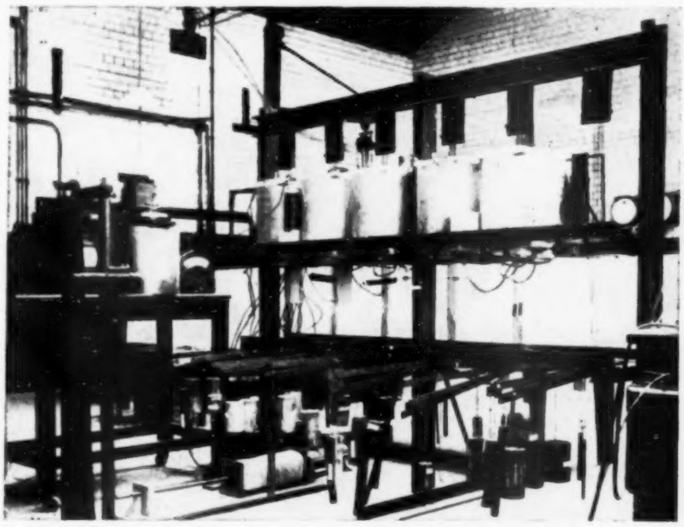

Fig. 1. General view of apparatus used.

The whole of the heating and straining equipment was supported on a stand constructed of steel channels and angles. The electrically heated furnaces were about 12 in. long and 12 in. in diameter, and were very thoroughly lagged. The alundum tubes, about 2 in. in internal diameter, were wound along their whole length with 16 turns to the inch of "Brightray" resistance wire, 0·037 in. in diameter; the total resistance of each furnace being 47 ohms. Of the six units on the stand, one was occupied by the wires being strained at room temperature, the other five being heated to approximately 100°, 200°, 300°, 400°, and 500° C., respectively.

In order to minimise the cooling effects of the ends of the furnaces, the tubes were provided with electrically heated plugs and insulating covers. The plugs were made of alundum cement, semi-cylindrical in shape, and about 1 in. long, each containing a heating element of the "Brightray" wire. In addition to these plugs, the three furnaces operating at the highest temperatures had end covers of "sil-o-cel" brick, into which further heating elements were grouted with alundum cement. As well as evening-up the temperature gradients, this arrangement rendered the furnaces more or less airtight, and only in the one at the highest temperature were slight oxidation and decarburisation apparent.

After repeated trials very satisfactory uniformity of temperature was obtained in all the furnaces, the working temperatures and respective voltages across which, on closed circuit, were :—

Furnace No.	Temperature, Deg. C.	Voltage.
1	103	23
2	205	29
3	308	41
4	412	45
5	514	50

Since the furnaces were all connected to the same source of electrical supply, fluctuations of temperature, due to the variations in the latter, would be greatest in the one at the highest temperature. A temperature record of this was therefore taken on a Cambridge thread-recorder, and a variation of less than 10° C. found. In view of the type of result obtained, there is no reason to believe that this was in any way material.

The straining arrangements adopted were as follows :— The wires were suspended from a plate, as shown in Fig. 2, by being looped round the shanks of the hexagon bolts, which latter were then screwed up tightly. The clamping bar and small screws were used to space the wires conveniently in the tube, there being six wires to each plate,

two of which were unstrained, and simply held in position by the clamping bar itself.*

As loads up to 250 lb. might be required direct loading was impossible, and a system of levers, four to each furnace, was fitted up, and Fig. 3 shows this arrangement fairly clearly. The common fulcrum, which was kept well oiled, consisted of a $\frac{3}{8}$-in. iron rod A. The levers B were made of 1 in. × $\frac{3}{16}$ in. iron strip, 30 in. long, pivoted about the fulcrum at one end, and separated from each other by means of the washers C. The fulcrum itself was supported at each end in wooden cross-pieces D, which were bolted to the framework of the stand. Lateral swinging of the levers was prevented by the vertical rods E passing between and fixed at their upper ends in the wooden strip F, which was itself attached to the cross-pieces D.

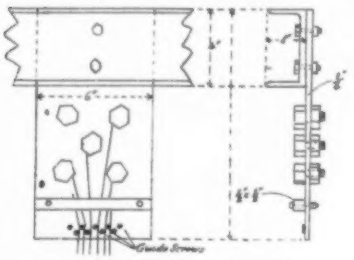

Fig. 2.—Wire suspension plate.

In each lever, exactly 2 in. from the centre of the fulcrum, a small hole was drilled and one of the wires under test G attached. By means of a system of rods and pulleys, small weights of a few ounces each were hung on to each of the unstrained wires to prevent them swinging about. The desired strain on the other wires was obtained by the use of a suitable weight suspended from the lever at the correct distance from the fulcrum. This distance was obtained by calculation—the weight of the lever itself being taken into account—and the stress in several cases was checked by means of a spring-balance.

The materials used in the tests were two 13-s.w.g. wires of the following compositions :—

	Wire A. %	Wire B. %
Carbon	0·39	0·15
Silicon	0·16	0·07
Manganese	0·63	0·59
Sulphur	0·024	0·016
Phosphorus	0·038	0·030

stressed, and one subjected—except in the case of No. 5—to one-half of the foregoing load. In air and in furnaces 1, 2, and 3, the loads represented, respectively, one-half and one-quarter of the tensile strength at room temperature, the stress at the higher temperatures being appreciably reduced. The details of the loads in tons per sq. in. are given in Table I.

According to the work of Tapsell and Clenshaw[2], the highest of these stresses for temperatures not higher than about 300° C. should be much lower than the limiting creep stress of the material at the temperature, and the lower stresses are beyond any doubt far below this value. At 412° C. the higher stress should have been slightly under the creep stress, though, in fact, slight creep, as will be mentioned later, was observed.

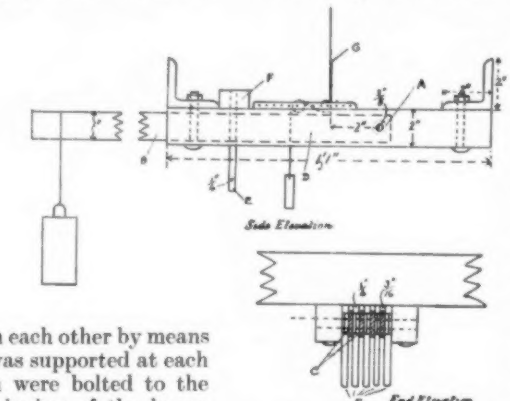

Fig. 3.—Lever loading system.

The more severely stressed wires originally placed in No. 5 furnace at 514° C. were overloaded and broke ; the times of fracture at varying loads are given in Table 2.

TABLE 1.

	Furnace Number.		
	Air, 1, 2, and 3.	4.	5.
A 1	16·8	13·4	5·4
A 2	8·4	6·7	4·26
A 3	Unstressed	Unstressed	Unstressed
B 1	14·4	12·1	4·7
B 2	7·3	6·05	3·65
B 3	Unstressed	Unstressed	Unstressed

TABLE 2.

Stress (Tons per Sq. In.).	Wire A.	Wire B.
8·4	3 days	—
7·3	—	3 days
6·05	8 days	—
5·4	Unbroken*	—
5·0	—	18 days
4·7	—	Unbroken*

*After 112 days.

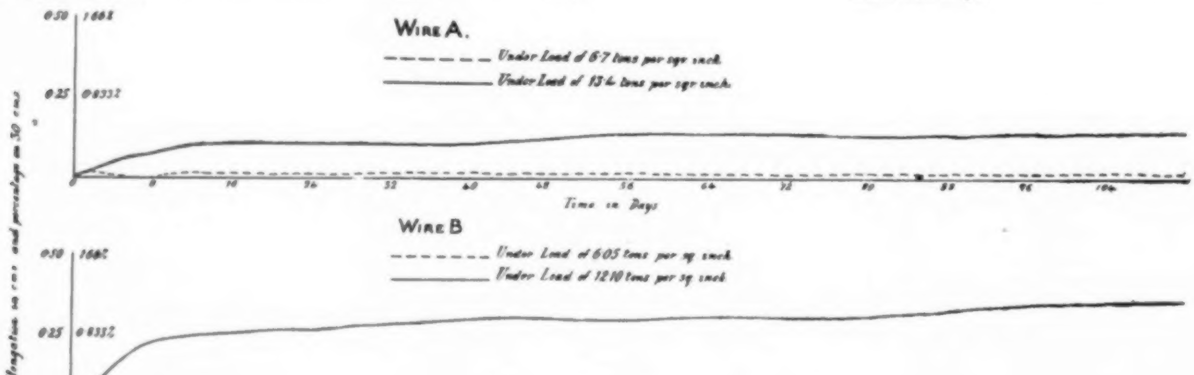

Fig. 4.—Creep at 412 Deg. C.

The original tensile strengths of these wires were 34·4 and 28·9 tons per sq. in., respectively.

In each furnace three samples of each material were under treatment, one of which was unstressed, one severely

All wires were marked below the furnaces with fine scratches and measurements of the creep made with a cathetometer twice a week. This was appreciable only at the temperatures of 412° and 514° C., the results for which are plotted in Figs. 4 and 5. These results are not regarded as being very exact measurements of the creep, but they

* This method of support had been previously used by Lobley and Betts ("Journ. Inst. of Metals, 1929, ii., xii., 157).

do serve to indicate the extent to which plastic flow has occurred.

These results suggest values for the limiting creep stress—if, indeed, there be such a thing—rather lower than those recorded by Tapsell and Clenshaw. Three possible explanations may be offered. In the first place, the tests now described were continued for more than 50% longer time than Tapsell and Clenshaw's; secondly, the present material has a rather abnormal structure which would, one would expect, lower the creep stress, and, finally, the present work was carried out on wire. It is believed that as the section of the test-piece is reduced the plastic deformation under a constant stress is increased.

The duration of the experiments was approximately five months, at the end of which time the furnaces were cooled and the wires removed. Actual measurements of creep could only be made over a period of 112 days.

In making the tensile tests, the elongation was measured with dividers on both a 4-in. and a 2-in. gauge length. The yield point was determined by the drop of the beam when the load was increased at a fairly slow, uniform rate, an Avery 6,000-lb. wire-testing machine being used.

YIELD POINT.

	Air.	103.	205.	308.	412.	514.
A I.	21·8	22·5	23·6	23·9	22·9	30·0
A II.	21·8	24·2	22·6	23·2	22·6	23·0
A III.	21·0	22·5	22·9	22·6	22·6	26·7
B I.	20·8	20·5	19·9	21·2	21·2	23·0
B II.	20·8	21·5	20·5	19·9	20·8	22·2
B III.	20·8	20·2	20·8	21·0	20·8	21·7

PERCENTAGE ELONGATION ON 4 in.

	Air.	103.	205.	308.	412.	514.
A I.	17	20	19	16	19	15
A II.	20	18	19	16	20	12
A III.	20	21	19	19	18	16
B I.	23	26	24	20	21	18
B II.	21	20	19	24	25	17
B III.	24·5	26	25	24	22	18

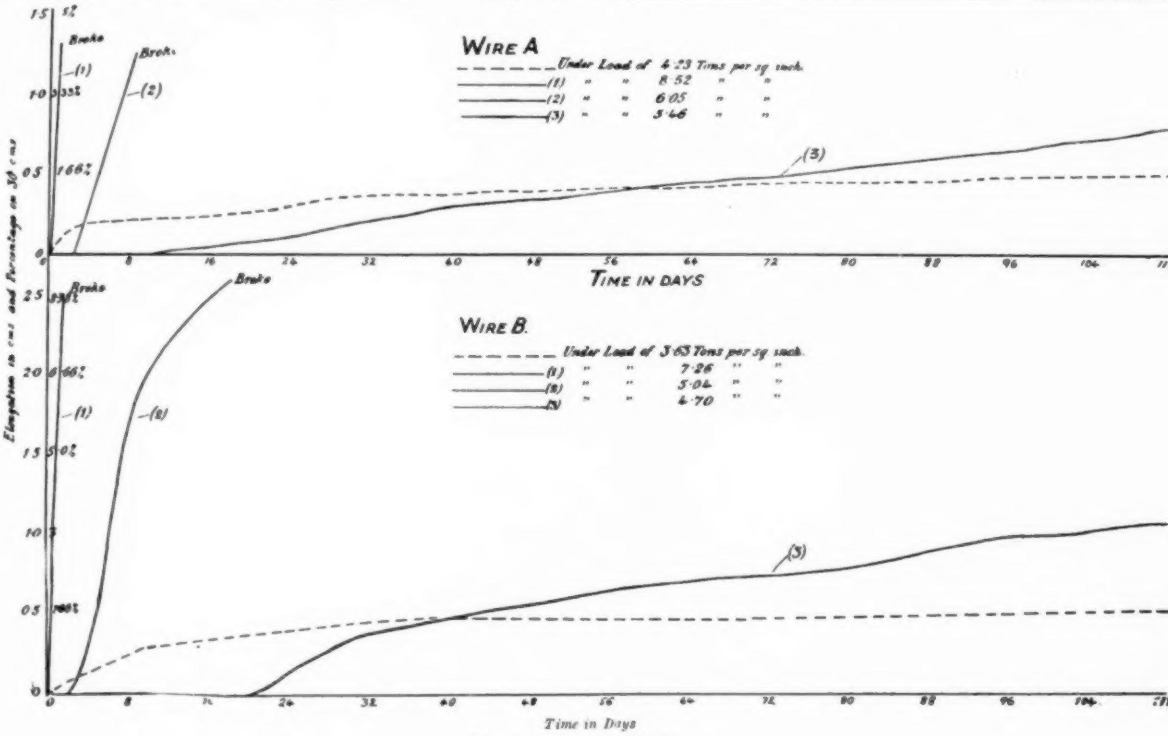

Fig. 5. Creep at 514 Deg. C.

Measurements of the reduction of area were effected by projecting an enlarged shadow of the fractured end of the test-piece on to a screen. By rotating the sample, several determinations of the diameter at the point of fracture were obtained.

In the few cases where the wire had scaled slightly, this was removed prior to testing by gentle rubbing with fine emery paper.

Results.

The results of these tests are tabulated below. In each case No. III. was unloaded, No. II. was under the light load and No. I. under the heavy load.

TABLE 3. TENSILE STRENGTH.

TEMPERATURE DEG. C.

	Air.	103.	205.	308.	412.	514.
A I.	34·7	34·1	35·3	34·4	34·2	33·7
A II.	34·9	35·7	34·6	34·5	34·2	33·8
A III.	34·4	34·7	34·8	34·4	33·7	33·7
B I.	28·6	28·3	27·5	28·3	28·1	28·2
B II.	28·3	27·5	27·5	27·9	27·9	28·5
B III.	29·1	29·3	28·6	29·0	28·4	27·6

PERCENTAGE ELONGATION ON 2 in.

	Air.	103.	205.	308.	412.	514.
A I.	21	22	24	22	25	18
A II.	25	22	21	19	22	16
A III.	22	24	22	22	24	20
B I.	28	27	28	25	26	25
B II.	27	23	27	27	31	23
B III.	27	31	28	28	28	26

PERCENTAGE REDUCTION OF AREA.

	Air.	103.	205.	308.	412.	514.
A I.	72·4	71·3	74·8	74·8	75·8	78·0
A II.	73·8	71·4	73·9	77·4	77·4	74·8
A III.	72·4	73·2	76·2	73·9	78·0	77·0
B I.	74·4	75·6	76·4	73·9	74·8	76·0
B II.	75·4	71·8	77·4	76·7	75·4	76·0
B III.	76·6	74·8	77·4	73·1	78·0	78·0

In no case was it possible to detect a change of microstructure before and after any of the treatments.

Conclusions.

A careful examination of these results fails to show any consistent influence of the load itself. Such changes as are to be detected are broadly common to all of the corresponding wires, whether unloaded, severely or lightly stressed. It would appear, therefore, that such variations of properties as may be observed are, in all probability, to be ascribed to the influence of the temperature alone. In Table 4, therefore, the mean results for the various temperatures have been collected and plotted in Fig. 6.

Table 4.

Wire A.

	Temperature Deg. C.					
	Air.	103.	205.	308.	412.	514.
Yield point, tons per sq. in.	21·5	23·1	23·0	23·2	22·7	26·6
Maximum stress, tons per sq. in.	34·7	34·8	34·9	34·4	34·0	33·7
Yield ratio	62·0	66·5	66·0	67·5	66·5	79·0
Elongation per cent. on 2 in.	22·7	22·7	22·3	21·0	23·7	18·0
Elongation per cent. on 4 in.	19·0	19·7	19·0	17·0	19·0	14·3
Reduction of area, per cent.	72·9	72·0	75·0	75·4	77·1	76·6

Wire B.

	Air.	103.	205.	308.	412.	514.
Yield point, tons per sq. in.	20·8	20·7	20·4	20·7	20·9	22·3
Maximum stress, tons per sq. in.	28·7	28·4	27·9	28·4	28·1	28·1
Yield ratio	72·5	73·0	73·0	73·0	74·0	79·0
Elongation per cent. on 2 in.	27·3	27·0	27·7	26·7	28·3	24·7
Elongation per cent. on 4 in.	22·8	24·0	22·7	22·7	22·7	17·7
Reduction of area per cent.	75·5	74·1	77·1	74·6	76·1	76·7

This process of averaging has the further advantage that incidental errors, due either to the experiment or to such factors as segregation, are largely eliminated.

Omitting, for the moment, the results obtained at 514° C., the most interesting feature is the very absence of any outstanding abnormality. This fact, however, far from lacking interest supplies a definite answer to the question as to whether "blue-brittleness" is a temporary feature. Provided that the stress does not cause appreciable plastic deformation, there does not appear, so far at any rate as these results go, to be any reason to believe that heating, even for prolonged periods, in this range leads to any marked permanent alteration of the mechanical properties.

Around 300° C., however, there are slight suggestions of embrittlement which may, of course, become greater with longer periods of test. So far as steel A is concerned, these indications consist of :—

(1) A small rise in the yield point to a low maximum, followed by a slight fall.

(2) A small maximum in the yield ratio. (It should be borne in mind that a yield ratio of 100 per cent. would indicate a completely brittle material.)

(3) A more definite fall in the elongation.

The same thing is shown for wire B, though rather less clearly by :—

(1) A slight maximum in the tensile strength ; and

(2) A small minimum in the elongation per cent., and the reduction of area per cent.

The most marked feature of the results is in connection with the values obtained at 514° C. At this temperature with both materials, but especially in the case of the harder steel, there is a definite increase in the yield point. Since the maximum stress has fallen slightly, there is a corresponding increase in the yield ratio to the very high value of 79%. The elongation also shows a marked fall of roughly 5%, which is, perhaps, rather greater with the most heavily loaded wire. It is curious, however, that the effect is not shown by the reduction of area figures. There is, therefore, at this temperature a definite indication of

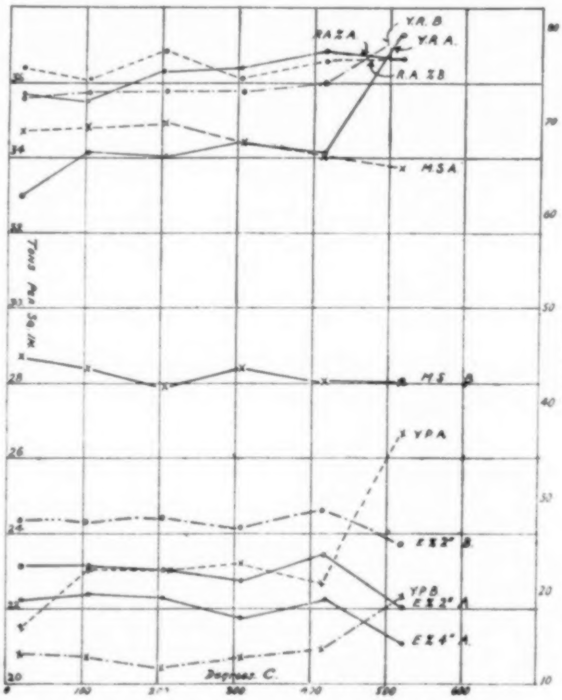

Fig. 6.—Mean Results Plotted.

permanent embrittlement, and it is, perhaps, noteworthy that it is at this temperature that the deep minimum is found in the impact-value-temperature curve. Although creep has taken place at this temperature, and although there are indications that the embrittlement just mentioned is greatest when the creep is highest, the following facts show that creep itself is not the sole cause of the effect found :—

(1) The increase in both the yield point and the yield ratio is shown by both of the unstressed wires.

(2) Both unloaded wires also show the decreases in the elongation.

(3) Creep also occurred at 412° C., at any rate under the higher stress, without, however, producing evidence of any permanent change of properties.

The small fall in the tensile strength at the highest temperature is most probably to be ascribed to the slight decarburisation already mentioned. It is in the face of this fact that the increase of the yield point, and the drop of the elongation at 514° C., are the more outstanding.

Broadly speaking, therefore, long-continued stressing below the creep limit at temperatures at any rate not higher than 412° C. produces no permanent effect on the mechanical properties, and cases such as the embrittlement of the bolt mentioned in the introduction, after such treatment, must be due to such causes as definite overstressing, vibrational fatigue, or possibly chemical attack.

BIBLIOGRAPHY.
1 Rosenhain and Hanson, "Journal Iron and Steel Inst.," 1927, ii., cxvi., p. 117.
2 Tapsell and Clenshaw, Dept. Scientific and Industrial Research, Engineering Research, Spec. Report No. 1, 1927.

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Economics and Politics.

THE close relationship of economics and politics may be regarded as a reason why the world's industrial depression has made itself felt in all countries. Yet the countries which have been most affected by competition with new manufacturing developments outside Europe have been those in which industrial evolution has been more advanced, either in that they have been more dependent on their exports or that their system of social organisation has been more highly developed. It is therefore not surprising that Great Britain, with her large amount of international commerce, should have been hard hit in the struggle, particularly in view of the policy of maintaining the value of the pound sterling, which had a serious effect on selling prices. Fortunately, the stability of Great Britain as a creditor nation has enabled her to withstand the economic conditions, but it is becoming increasingly manifest to all thoughtful people that a rigid tightening-up of expenditure is long overdue. The want of balance in the economic relationship has placed Germany in a precarious position, primarily because she is a debtor nation. She is oppressed with war debts, and other countries are either unable to buy her products to the extent that would assist in her resuscitation, as a result of fierce competition; or other countries are producing more for their own requirements. France, on the other hand, has not felt the want of balance so rapidly, either because her producers benefited from the fall in money values or because her economic constitution and political conditions isolated her, to some extent, from the world.

In regard to Great Britain, one of the reasons for a want of confidence, without which industry will never be restored, is the increasing weight of taxation in one form or another. Every pound saved by the Government or the municipality goes, when once the balance of revenue and expenditure is reached, in favour of less taxation or rates. At present the burden is very heavy and, certainly, in regard to taxation, greatly exceeds that of any other country. Even so, political considerations have placed us in an unenviable position, and expenditure is likely to exceed revenue by a very considerable amount. The present weight of taxation is so heavy that it is a serious menace to progress, and it can only be reduced by peace, thrift, and united effort. It is, however, first of all necessary to endeavour to restore equilibrium between revenue and expenditure, and drastic proposals to this end are made in the report of the Economy Committee. This Committee have had a thankless task and, however distasteful its recommendations may be, its members are to be congratulated on their courage for the lucid, almost blunt, manner in which the recommendations are made. There is nothing ambiguous about the statement in the report that "the country must face the disagreeable fact that the public expenditure—and in this we include local as well as national expenditure—is too high, and that it must be brought down to a lower level," that "existing financial difficulties make it necessary for the nation, like the private individual, to consider seriously what it can afford, and not merely what is desirable," and further, that "the general effect of Government action since 1924 has been to add to the national burdens. These have now attained to such a proportion of the total national income that they must be considered definitely restrictive of industrial enterprise and employment." These statements in themselves may be taken as mere platitudes, but the drastic recommendations made in the report are a significant reflection on any such attitude. It states that only by the strictest regard to economy and efficiency over a long period can the trade of the country be restored to its pre-war prosperity, and any substantial number of the unemployed be reabsorbed into industry. The recommendations are too well known now to be discussed here, and all will appreciate their far-reaching possibilities, but economies of such dimensions as are referred to can only be effected by a united effort. The report urges that if the national situation is to be saved the recommendations must be carried out as a connected programme. However much these proposals may be deplored in many quarters, confidence in the stability of the finances of this country must not diminish, and a united House of Commons should take whatever measures are necessary to balance revenue and expenditure and ruthlessly cut out all avoidable expenditure.

Coinciding with taxation is the heavy weight of debt and the doubt whether those countries to which we export material and products can pay for them without long credits which hamper production and the improvement of trade. At the moment many countries in Europe and parts of Asia are in a state of desperation, and a strong effort is required to give any chance to these nations. The gesture made by President Hoover was an acknowledgment that the United States of America could no longer maintain its isolation from European industrial difficulties. It has grown rich at a grave risk to its own trade and at the expense of the world, and, together with France, has given a great fillip to the cause of peace and to the possibilities of industrial co-operation by giving assistance and credit through Great Britain which will, at least, assist in restoring the financial status of Germany.

The laws of economics apparently condemn without appeal, as in the case of superfluous plant and equipment, and in many instances whole factories. This applies chiefly to those which are being used under conditions that are not justified by the present state of international competition. It is sometimes assumed that by allowing events to follow their natural course this excess of plant and factories will be eliminated as time proceeds, but we are not living in a world entirely subject to exact economic laws; other factors have to be considered, and these are sometimes more important. Thus, for instance, political movements, when they are able, frequently oppose the modifications brought about by economic causes, and often effectively. Under present conditions the first thing needed is to secure a return to prosperity, and whatever sacrifices may be recognised as necessary to effect economic security should be decided and acted upon, and thus put an end to a policy of drift that will otherwise more seriously affect British credit and further restrict industrial enterprise and employment.

Business Administration.

Slowly, but with gathering momentum, an industrial revolution is taking place; great combinations for production are coming into existence, fusion of banks and industries to provide the credit and means of exchange required for large industries, amalgamations of allied industries and of industries within themselves. The competition of manufacturer with manufacturer within a narrow area is gradually giving place to combined efforts in production to supply home wants and to compete with other countries and their industries. The fact that the world is in the throes of a severe industrial depression is actually intensifying the desire to organise on colossal lines to cut out the obsolete and remove the redundant. The present low prices and keen competition between one country and another may further assist the industrial revolution by increasing the possibilities of international co-operation. Certainly the spirit of combination is developing rapidly, and it is difficult to forecast how far it will proceed.

With this rapid development in industrial organisation, scientific and technical progress has been an outstanding feature. But this rapid growth has raised many problems that are not easy of solution, and notably is this true of the problems associated with administration. The structure and operation of the modern organisation are highly complicated, and it is becoming increasingly necessary that the administrative staff should be fully qualified to understand their complexities, maintain the delicate structure, and guide the operation of the organisation along successful and profitable channels. Thus, however much we may be tempted to extol the efficiency of our scientific and technical workers and the skill of our craftsmen, unless their energies are directed along profitable paths their potential value is not effectively employed.

Modern industry requires administrative vision, and calls for judgment of a high order as well as some knowledge of specialised branches, and it is becoming increasingly essential that industry must be controlled by an administrative staff trained to meet and overcome the complex problems of big business. There is some difficulty in obtaining trained personnel, and it is gratifying to learn that the London School of Economics has established a Department of Business Administration. This important venture in education for business management is the result of joint efforts by a number of important firms and business leaders, acting together with the academic authorities of the School, with a view to developing the systematic study of current business and to training suitable young men and women for responsible posts.

The teaching will be organised from the standpoint of the individual firm, and will include a study of the basic principles of administration and organisation, executive control, and the problems involved in adapting a business to external changes, such as occur, for example, in market conditions. The Department has been fortunate enough to secure the assistance of a number of well-known representatives of business who will open a series of informal discussions. The discussions will include, for example, marketing, retail distribution, modern accountancy problems, advertising problems, banking policy, and practical aspects of importing and exporting. These discussions will assist students to gain an insight into the way business men handle problems, and will show the technique employed in dealing with various practical issues in a practical and business-like way.

This development is an experiment, but one which should contribute to the better permanent training of industrial personnel and to the recovery of British industry from the post-war depression.

International Association for Testing Materials.

The first Congress of the New International Association for Testing Materials to be held in Zürich from September 6 to 12, is an event of more than ordinary importance. This Association was formed following a Congress held in Amsterdam in 1927 with the object of holding Congresses every three or four years in order to present reports, promote discussions, and to interchange ideas and information on the subjects relating to the testing of materials. It is, in fact, another indication of the international co-operation that is developing gradually in the technical and industrial spheres. Papers will be presented by distinguished authors, the choice of subjects having been decided upon by the Permanent Committee of the International Association. Discussions are invited, both written and verbal and should prove of infinite value, as in some cases as much as 3½ hours will be devoted to one set of questions. One section deals entirely with metals. The five selected subjects are the Progress of Metallography, Materials at High Temperatures, Cast Iron, Fatigue, and Notched Bar Impact Tests.

The leading authorities of the various countries have been invited to furnish official reports on these subjects, advance copies of which have already been circulated to members of the New International Association for Testing Materials and to all others who have signified their intention of attending the Zürich Congress. It has been thought that by thoroughly discussing a few subjects more lasting benefit would be derived by those attending the Congress than would be the case if a great variety of subjects were dealt with. This policy is not always possible, but it is a policy to adopt when, as in the case of the Zürich Congress, it is possible. When papers are not adequately discussed their value is lessened, and the authors cannot feel completely satisfied. Dr. Rosenhain will preside over the metal section and important reports will be given by Dr. Gough, Dr. Greaves, Dr. J. L. Haughton, Mr. R. G. Batson, Mr. J. G. Pearce, all well-known British authorities. The Congress ought to be one of the most successful of its kind ever held and should be of great technical and practical value.

Forthcoming Meetings

ROYAL AERONAUTICAL SOCIETY.

Sept. 16. The Wilbur Wright Memorial Lecture, to be delivered by Mr. Glenn L. Martin, his subject being, "The Development of Aircraft Manufactuing," at 9-15 p.m., in the Science Museum, South Kensington.

IRON AND STEEL INSTITUTE.

Sept. 29 to Oct. 2. The autumn meeting will be held at Swansea, for which a comprehensive programme has been prepared.

INSTITUTE OF METALS.

Sept. 13—15. The annual autumn meeting, to be held at Zürich. The tenth autumn lecture will be delivered on September 13 by Mr. Ulick R. Evans, M.A., on "Thin Films on Metals in Relation to Corrosion Problems."

The new International Association of Testing Materials.

Sept 6—12. The first Congress to be held in buildings of the Swiss Federal Polytechnicum, Zürich, under the presidency of Professor A. Mesnager. The work of this Congress will be in four groups—viz.: Metals: Chairman, Dr. W. Rosenhain. Non-Metallic Inorganic Materials: Chairman, Professor M. Ros. Organic Materials: Chairman, Professor J. O. Roos. Questions of General Importance: Chairman, Professor W. von Möllendorf.

INTERNATIONAL FOUNDRY EXHIBITION.

Sept. 12—16. International Foundry Congress to be held at Milan.

Correspondence.

STEEL FURNACE REPAIRS.

The Editor, Metallurgia.

Dear Sir,—The article by Mr. Walter Lister on the above subject in your current issue is one of the extremely few published dealing with a phase of steelworks practice which has much bearing on the ultimate cost of melting. The degree of intelligence used in repairing a furnace will usually signal the class of melter in charge.

Perhaps I may inform users of electric arc furnaces of an effective way of preserving the bottom of their plant if it is being "upheaved"—to use Mr. Lister's expression—by a boil on the bottom. I see no reason why, rather than suffer the total loss of a heat of open-hearth steel, mentioned in the article as the occasional result of a very severe boil on the bottom of an open-hearth furnace, the same remedy should not be adopted in that type of furnace.

A boil on the bottom of any steel-melting furnace makes the average melter "fair sweat." It made me do so years ago at a most inopportune moment, shortly after taking temporary charge of a molten heat of steel in a large electric arc furnace. I had taken over the furnace because I considered the melter was conducting the process stupidly; and my upset at being, so soon after, faced with a mountainous geyzer inside the furnace, and with a grinning deposed melter winking to his mates behind me, can be imagined. I recalled that whilst the melter had been in charge he had drastically oxidised the bath, adding ore beyond reasonable requirement. Good fortune or good judgment dictated trying a rapid deoxidation. Ferro-silicon was thrown into the bath, and in very few seconds the boil entirely disappeared.

I maintained the bath in its deoxidised condition for a few minutes to consolidate, as I hoped, the disturbed portion of the hearth, and then gently re-oxidised and completed the melt in normal manner. The bottom required very little repair after the heat.

On every occasion since then that a boil has threatened the hearth of a furnace, a lump or two of ferro-silicon has settled the dispute. A number of friends to whom I have recounted the facts since those days have adopted the same routine, and a boil does not now wreck their melters' equanimity.

Reading carefully Mr. Lister's article, and taking into cognisance one's own experiences, the reasonable conclusion is that such boils are the result of the presence of an oxide in contact with the refractory under conditions favourable for an attack by the former on the latter. The remedy is, apparently, indicated.

I should be glad to hear that an open-hearth metallurgist will try the suggested remedy when his next furnace misbehaves. It is more difficult to deoxidise in such a furnace than in an electric one, but the result may be good for everyone's health!—Yours etc.,

Dunston-on-Tyne. Victor Stobie.

The Editor, Metallurgia.

Dear Sir,—I was very pleased to have Mr. Victor Stobie's comments and valuable criticism on my article in last month's Metallurgia. But I am afraid that he has just failed to see that I was particularly talking about the danger of leaving "old dogs" in the bottom. These undesirable animals that haunt a melting-shop are large masses of steel covered over with a thin layer of fettling material by some lazy melter. Instead of splashing a hole out clean, he covers the pool of steel up and hopes for the best. The best is that it may last a charge or two, but inevitably it boils out again, and the hole is found to be deeper than before. The same covering-up process is gone through, and the next time it boils out it may go through the bottom—and no amount of ferro-silicon will stop it.

I pity the melter—or the furnace manager, for that matter—who knows of the existence of these "old dogs."

The use of ferro-silicon for stopping a "boil" was a general practice in the open-hearth long before the advent of the electric furnace. But in the basic, owing to the corrosive effect of the silica formed on the oxidation of the ferro-silicon, it was found more satisfactory to use lumps of clean heavy steel scrap. But these expedients can only be used on the open-hearth in the case of boils in the breasts or banks. The lump of ferro-silicon or scrap is dropped into the hole by means of a long shovel. This has a chilling effect, and the boil immediately subsides. A covering of sand or dolomite (as the case may be) is then put on top. This will usually keep the charge quiet until the furnace is tapped, after which the bad place can be cut out and properly repaired. These boils in the banks may be due to various causes, such as silica running from the side walls, dirty scrap resting on the banks, careless feeding of mill scale or iron ore, but a boil in the bottom, due to an "old dog," is quite a different proposition, and is simply the mechanical effect of a high temperature overcoming a thin layer of covering material and so melting up the steel beneath, which, being at a lower temperature, is thrown up somewhat in the manner of a fountain. Some bottom is thrown up at the same time with the result that in extreme cases the charge percolates through to the plates and so breaks out.

In the case quoted by Mr. Stobie as "the bottom required very little repair after the heat," evidently there had been no hole at all. From this I am inclined to the belief that the cause of the commotion was simply unmelted scrap boiling up off the bottom, a phenomenon we often come across in steel-making.

I take this opportunity of saying that I will be pleased to receive any further criticism, or will be prepared to give advice on any subject mentioned in any of my articles, as I believe in this way much good can be done towards elucidating many problems connected with the melting-shop.—Yours etc.,

Mansfield, Notts. Walter Lister.

The Phase-Theory Basis of Ageing of the Duralumin Type in the Ternary System.

The article under the above title, which was published in our March issue, has evidently been of considerable interest to many of our readers, and, in response to correspondence, we desire to state that it was translated from "Die phasentheoretischen Grundlagen der duralumin-artigen Vergütung im Dreistoffsystem," which was published in *Zeits. f. Metallk.*, in September, 1930, and the author of the article, whose name was inadvertently omitted, was Dr. E. Scheil.

In multiple systems, to which duralumin belongs, several types of crystals may separate out alongside one another. The view has been expressed that the change in concentration of the supersaturated solution, due to the separation of one type of crystal, can influence the separation of the other type, and, in this article, the author considered the way in which this influence can affect the course of the separation.

Associated British Machine Tool Makers, Ltd.

From the advertisements of the Churchill Machine Tool Co., Ltd., and Messrs. Kendall and Gent (1920), Ltd., which appeared in our July issue, mention of the name of the Associated British Machine Tool Makers, Ltd., was inadvertently omitted. These firms are members of the Associated British Machine Tool Makers, Ltd., which is their foreign selling organisation.

Aluminium Sheet Production

By Robert J. Anderson, D.Sc.

Part IX.—The Hot Break-down Operation.

Practice at the hot-mill in rolling aluminium ingots to slabs, including rolling temperatures, drafts and passes, lubrication of ingots and cooling of rolls, slab thicknesses, and man-power requirements, is discussed in this article.

ALUMINIUM and aluminium-alloy rolling ingots are broken down to slabs at suitable elevated temperatures as a preliminary step in the production of sheet. With one exception to be pointed out later all rolling operations, starting with the slab, are performed cold—*i.e.*, at room temperature. The object of the hot break-down operation is twofold, viz., (1) to destroy the as-cast structure—or "make the metal," using the terminology of steelworks practice; and (2) to produce a slab having the desired thickness and size, which is suitable for further processing by cold rolling.

As will be understood by those conversant with rolling-mill work, the details of hot-mill practice are inextricably woven with the machinery employed and the planning of production. For convenience in discussion, it is advantageous to consider the three main divisions of hot-mill practice (*i.e.*, the actual rolling, the mills and auxiliary equipment, and the planning) separately. Accordingly, in the present article, the details of the hot break-down operation are dealt with; in the next succeeding article (Part X.) mills and equipment will be described, and in the second succeeding article (Part XI.) the methods and problems of planning will be discussed. Although of much practical importance, the more theoretical aspects of metal-rolling processes cannot be given attention in these articles, owing to the confines of space; in this connection, however, reference may be made to the discussion by Caswell.[1]

At the outset, it should be stated that an aluminium hot-mill is not hot in the sense that the rolls are heated—other than by contact with the ingots,—but it is so called because the ingots are rolled at some elevated temperature.

The production of slabs by hot-rolling aluminium ingots must be carried out according to definite plan. In some works the details of the rolling are prescribed by the planning department solely. In other mills the planning is worked out in part by a clerk (in the mill office), who "figures orders," and in part by the hot-roller. The former method is preferable. All details of the passing should be standardised, covering the rolling of various sizes (of slabs), and the hot break-down order sheet may well indicate the roll sets. It is of rather more than passing interest in this connection to point out that, not so long ago, aluminium hot-rollers were regarded as almost sacrosanct—in a class with the old-time brass slab casters. In former years temperamental hot-rollers often did as they pleased, expending their energies rather more largely in delaying production, rolling wind, eating lunch, taking rests, giving advice, quarrelling about the metal, breaking rolls, and having general good times, than in producing slabs. With the development of systematic planning in aluminium mills, the necessity of relying on men whose stock-in-trade consisted merely of an empirical knowledge of roll sets—more often wrong than right—has disappeared.

An aluminium ingot may be hot rolled by giving it one to three passes so that the original width or length is extended sufficiently to make the desired width of the slab, whereupon this resultant thick slab is turned at right angles to the original direction of rolling and cross-rolled to the desired thickness, the length being allowed to run. Or the ingot may be given a fairly heavy pass in one direction, then turned 90° and rolled to width on one or two passes, and then rolled in the original direction of passing to thickness. The total number of passes required in the break-down operation may be from about five to nine for aluminium ingots; hard alloys require lighter drafts and, consequently, more passes.

In discussing hot-mill practice here, it is of interest to consider such matters as rolling temperatures, drafts and passes, lubrication of ingots and cooling of the rolls, slab thicknesses, and man-power requirements. These items are dealt with under appropriate headings below.

The Hot-Mill Crew.

The number of hands required to operate an aluminium hot-mill varies, depending mainly on the type of mill, auxiliary equipment, and the speed of production demanded. With two-high and three-high mills four men are ordinarily employed, viz., a roller, two catchers, and a screw boy, the latter being so called regardless of his age. In the case of

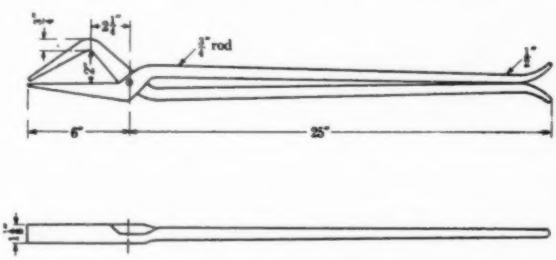


Fig. 1—Hot-mill Tongs.

the double-duo mill—to be described in a subsequent article—the crew consists of two rollers, three helpers, one elevator operator, and a screw boy. Irrespective of the type of mill, production requirements demand that vertical motion of the upper roll be imparted by power-operated screws, so that time will not be lost in making laborious adjustments for the roll-set by hand (*i.e.*, with notched wheel and hand wrench). When the screws are driven by motor the function of the screw boy is to operate the hand controller which starts and stops the motor. In the case of two-high reversible mills the screw boy also operates the hand controller, which reverses the main drive of the mill. Where movable tables are used, as on three-high mills, the screw boy handles the controlling mechanism governing the raising and lowering of such tables. The roller has charge of the mill, and acts as the foreman of the crew.

In breaking down on two-high irreversible mills the roller passes the ingot through the rolls on his side of the mill, and it is received by the catchers on the opposite side. The partly broken slab is then lifted so as to ride on the top roll and shoved back to the roller by the catchers. Passing and returning are continued until the slab has been rolled to the desired size. After each pass the upper roll is lowered through operation of the motor control by the screw boy. After rolling the catchers lay the slab on a pile. The metal is handled with tongs. If ingots are trucked to the hot-mill from a preheating furnace, a trucker or helper

[1] J. S. Caswell, "The Rolling of Metals," *The Engineer*, vol. 149, 1930, pp. 232-234; 260-262; 288-289; 316-318; 342-344; 369-370.

is needed for handling the ingot buggy and dumping the ingot on the mill bed.

In rolling on two-high reversible mills the catchers return the partly broken slab to the roller by passing it through the rolls instead of over the upper roll, the upper roll being lowered after a pass in either direction. The operation is otherwise the same as on two-high irreversible mills. Rate of production, as is obvious, is considerably greater on the former type of mill. Three-high mills are equipped with movable tables, which are raised and lowered so that the ingot can be passed between the upper two rolls in one direction and the lower two rolls in the opposite direction. In rolling on a double-duo mill the

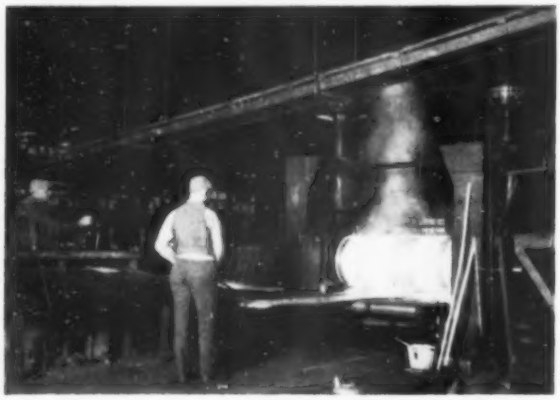


Fig. 2.—Roller's side of two-high reversible hot-mill.

ingot is started through the lower pair of rolls, it emerges on an inclined table and is then discharged on to a movable platform table. This latter table is power-operated, and may be elevated and lowered as required. The table is down when the slab is coming from the front of the mill, and up when it is being sent back. This table is elevated to the proper position and the ingot is passed through the upper pair of rolls, being returned on this pass to the roller on the opposite side of the mill. A roller and a catcher may work on opposite sides of the mill (*i.e.*, two men on each side), and an elevator operator may control the movable platform. Roll-set is made by the screw boy. The number of men employed on the double-duo mill depends considerably on the arrangement of the controls for the roll-set and the elevator.

Many attempts, largely abortive, have been made to reduce the number of hands at the hot-mill, in order to cut labour costs. The usual methods employed for doing away with man power at the hot-mill involve the use of movable feed and return tables, mechanical catchers, and other pseudo-robot mechanism, which, in most all examples that the writer has observed, are more bother than worth. Numerous contraptions, designed to eliminate hand labour, have been built and attached as auxiliaries to hot-mills, but in practically all cases they are either so expensive of first cost as to allow no saving, or are continually getting out of order. Too, such devices often fail to function as claimed, or they reduce the rate of production so much as to be of no value at all.

Probably the extreme example of trying to eliminate hands at the hot-mill is found in a plant where the attempt is made to perform the break-down operation on a two-high irreversible mill with only one operator. The mill foreman, or a stray labourer, is supposed to stand by and help " in case anything happens." The device for accomplishing this miracle of labour-saving consists of a combined mechanical catcher and throw-over table, the function of which is to receive the slab after the rollers pass, elevate it, and permit it to slide down over the upper roll and be received by the roller preparatory to another pass. In the operation the single operator removes an ingot from a preheating furnace back of the mill, trucks it to the feed table, adjusts the screw-down for the roll-set, and makes the pass; the mechanical catcher returns the slab; and, after the final pass, the roller runs around to the opposite side of the mill, pulls the slab off the catcher, and lays it on a pile. Unfortunately, the mechanical catcher often fails to move, so that a couple of men have to grab tongs and lift the slab over the roll, or it rises with a violent jerk, hurling the slab back to the roller or on to his feet. As observed in operation, this business is unbelievably slow, and the help of the man who " stands by," as well as several other men, is usually required to keep affairs in working order.

Nothing is gained by trying to operate a hot-mill short-handed. On a two-high irreversible mill a crew of four men (a roller, two catchers, and a screw boy) can roll, say, 250 ingots in 10 hours. On a two-high reversible mill, such a crew can roll upwards of 400 ingots in the same time. Of course, various factors, other than the number of hands employed, affect the rate of production, as will be seen more clearly from the subsequent discussion. Important factors are the size of the slabs, and whether the rolling is continuous or intermittent.

Fig. 1 shows a form of tongs suitable for use in handling ingots and slabs at the hot-mill. Fig. 2 shows a view of the roller's side of a two-high reversible mill. The controls for regulating the roll-set and for reversing the mill are situated close together, so that they can be easily operated from a pulpit by the screw boy. In the photograph an overhead inclined conveyer will be noted. This delivers the ingots to the mill. An ingot may be seen in front of the left-hand housing of the mill.

Hot Break-down Temperatures.

Hot-rolling temperatures for aluminium and aluminium-alloy ingots have been the subject of no little controversy and considerable experimental work. Practice varies more or less in different mills, being influenced considerably by local conditions. The object of rolling ingots at some elevated temperature is, of course, to increase the plasticity of the metal, thereby either permitting its shaping or increasing the speed of shaping over that possible at some lower temperature. Thus, duralumin ingots cannot be broken down cold, but can be rolled into slabs satisfactorily at about 450° C. Also, aluminium ingots can be hot rolled at 400° C., or less, but the operation proceeds better and heavier drafts can be taken at 460° C. There is, naturally, an upper limit of temperature which cannot be exceeded because of the onset of hot-shortness.

The range of temperature employed in practice for the hot break-down operation on aluminium and alloy-sheet ingots may be taken as 400° to 525° C. Ordinary 99+% aluminium can be hot rolled satisfactorily over a considerable range of temperature, but many years of practical experience indicate that the best all-around temperature is about 455° C. Alloys of the heat-treatable type, like duralumin and other hard compositions, are usually hot rolled at somewhat lower temperature than aluminium. These alloys are both hot-short and cold-short, consequently the hot-rolling range is limited. In one plant 2 S ingots are broken down at 475° C., and duralumin ingots at 450° C. Lean alloys of the heat-treatable type, like Aldrey or 51 S, may be rolled very nicely with the same practice as employed for 2 S. The alloy 3 S may be broken down satisfactorily at about 465°—470° C. At one plant Silumin is hot rolled at 510° C. In another mill the 95 : 5 aluminium-silicon alloy is hot rolled at 475° C. The most satisfactory hot-rolling temperature for a given composition and given fixed conditions may be readily determined by rolling ingots over a considerable range of temperature, followed by mechanical and performance tests on the resultant sheets. In any mill hot-rolling temperatures should be held within narrow limits, depending on the specific conditions, thereby eliminating one variable of operation.

(*To be continued.*)

Iron and Steel Foundry Practice

By Ben Shaw

Part VIII.

Comparison of Converter, Open-hearth Process, and the Electric Furnace.

THE steels used in the production of castings vary much in their composition and characteristics, but broadly, they may be divided into two main groups—carbon steels and alloy steels. The carbon steels are invariably low in carbon, rarely exceeding 0·5%. They are, in fact, comparable with structural steels in composition, and are distinct from tool steels, which have a higher carbon content. Although steels used for castings are low in carbon and in a wider consideration of steel would be referred to as a mild steel, they are subdivided by the foundryman into three grades—soft, medium, and hard steels. These terms are merely applied to indicate a relative comparison between steels suitable for different classes of castings. Thus, a soft steel, capable of offering considerable resistance against shock, may contain carbon up to 0·25%; a medium steel, possessing greater rigidity, with carbon up to 0·35%; whereas a steel having 0·5% of carbon, of increased strength, is hard by comparison.

Special or alloy steels are distinct from carbon steels because of special characteristics produced in them by the addition of one or more alloying elements to their composition, the most outstanding of the elements commonly used being nickel, chromium, molybdenum, etc., while manganese and silicon steels, in which these elements predominate, have many uses.

Although there is a considerable similarity in the processes employed in the production of iron and steel castings, there is an outstanding difference in melting practice. In addition to mixing and melting, which are common to each process, refining is an essential stage in the process of steel making. The raw materials, such as pig and scrap iron, are relatively high in carbon and other elements, and these must be reduced during the refining stage to convert the charge into steel. Thus, in the preparation of molten steel to meet requirements for castings, the work may be conveniently divided into three stages: the selection of the charge, melting, and refining.

In practice, the fluid metal is prepared by one of three processes—the converter, open-hearth process, and by the electric furnace. Each process necessitates a different technique in operation, the methods of melting and refining differ, and the charge must be varied to suit the particular process, and whether the hearth of the melting plant is acid or basic. It is not possible to state without qualification which process is the best, as production costs and quantities have to be considered as well as quality; but a brief comparison of the relative merits of the three processes will be helpful in estimating the value of each.

The converter process has the advantage of flexibility. It can be shut down or started up day by day as desired, with little effect on economy or life of linings. It provides small quantities of very hot metal of great fluidity, which facilitates the action of alloys used to deoxidise the steel. By this process the steel contains more oxides, occluded gases, and silicate inclusions than open-hearth or electric-furnace steel, but to a certain extent its greater fluidity renders their elimination easier. It requires a low area of casting floor for a given rate of output. It is more particularly suitable for foundries dealing with small intricate castings. The open-hearth process is more suitable for dealing with large quantities of metal at one heat, and is therefore more applicable for the preparation of steel for large castings. It is possible to maintain close control over the composition, which enables the manufacture of steels of higher grade than is the regular practice with a converter. Adopting the basic process, the lowest grade scrap may be charged to produce high-grade casting steel. This process is the most economical method of manufacturing steel when casting metal is required in large quantities.

The electric-furnace process more nearly resembles the open-hearth process, particularly during the earlier stages, but it gives advantages in manufacture of steel that are not obtainable to the same degree in open-hearth furnaces. It enables the temperature to be controlled more accurately, has a better control of the analysis of the charge, and facilitates the removal of sulphur. The cost of manufacture is relatively high, dependent upon the price of power, but when high-grade castings are required the increased quality compensates for increased production costs. As a rule, however, the removal of impurities, which results in the production of a high-quality steel, increases the difficulties associated with the making of castings. This is due to the fact that high-quality steels have a low range of fluidity, and do not feed well when poured into mould: converter steel, on the other hand, is more fluid, and feeds well by comparison. Although the difference in the contents of impurities in steels made by the three processes is relatively small, their influence varies considerably. The approximate contents of impurities of steels made by various processes, and which, according to Mr. Cance,* may be taken as the average, are as follows:—

Process.	Electric Furnace.	Acid Open Hearth.	Converter.
Sulphur	0·020	0·045	0·060
Phosphorus	0·020	0·040	0·055
Oxygen	0·025	0·040	0·080
Total	0·065	0·125	0·195

The general principles involved in the manufacture by each process can with advantage be considered in greater detail; it is necessary, however, to discriminate between acid and basic steels, as these are the product of two different and sharply defined classes of raw materials, although made by processes which in principle are the same. Whatever method is adopted, the finished steel is required to meet the same specifications.

In the acid process, the principal factor in the working is silica, which is an acid material, the hearth of the furnace being made up with sand, which should not contain less than 95% of silica. It is not possible to eliminate phosphorus or sulphur from a charge in an acid furnace: thus, the raw materials must be low in phosphorus, which necessitates the use of hematite pig and scrap, as well as steel scrap, with a low content of phosphorus and sulphur. In the basic process lime and magnesia, or a natural mixture of dolomite, are used to form a basic hearth. By this process not only can phosphorus be eliminated, but

* Proceedings of Institute of British Foundrymen, Vol. xxii, page 615.

sulphur can be reduced, though it should be kept reasonably low, and thus much cheaper raw materials can be used.

Converter Process.

With the exception of the Stock converter, in which the charge is melted direct, the converter process is used solely to refine the metal which is previously melted in a cupola. The cupola is charged with pig iron and scrap, with or without steep scrap, and it is necessary that they should have low sulphur and phosphorus content, because this process is invariably acid. When the charge has been rendered fluid it is transferred to the converter. The principle of this process of conversion into steel is the oxidation of carbon, silicon, and manganese in the charge as a result of air blown into the converter. The process depends on the heat generated by the combustion of these elements, chiefly carbon and silicon, and the composition of the charge should be regulated to give an amount of combustion which will effect conversion and give a reasonably hot blow. The carbon content is usually over 3·0%, but it is necessary to watch the silicon content. When the charge contains no more than 1·0% of silicon there is a risk of a cold blow, while with, say, 3·0% silicon the reaction is so great that the blow may be too hot and much of the charge lost through the nose of the converter. Normally, the silicon content should be about 2·0%.

The reactions effected during a blow are very complex, and although what actually takes place inside the converter cannot be determined with accuracy, there can be no doubt that the charge is oxidised in the mass at the outset, and in this way oxygen comes into contact with the silicon, manganese, and carbon, and generates heat. Theoretically, the number of calories per kilog. produced by the reactions may be taken as follows :—

$$\mathrm{Si} + \mathrm{O}^2 = \mathrm{Si\ O}^2 + 7{,}000 \text{ calories.}$$
$$\mathrm{Mn} + \mathrm{O}^2 = \mathrm{Mn\ O} + 1{,}653 \text{ calories.}$$
$$\mathrm{C} + \mathrm{O}^2 = \mathrm{CO}^2 + 8{,}100 \text{ calories.}$$

The conversion is, however, very complicated in practice, and other factors influence the heat efficiency obtained. It is recognised, for instance, that not all the carbon is burned directly to CO^2; much is removed as CO, with consequent loss of heat.

As the converters used in steel foundries are invariably acid lined, the charge of iron must be low in phosphorus and sulphur ; for this purpose the cupola is charged with hematite pig and scrap known to be low in these impurities. As a rule, hematite pig irons have a comparatively high silicon content, and although about 10% of the silicon in the charge may be lost in passing through the cupola, the content is likely to be too high for satisfactory conversion. To reduce the content, it is customary to use a percentage of steel scrap with the cupola charge. A considerable loss is effected in the conversion process, as in addition to a loss of 3 to 4% in passing through the cupola, there is a loss of about 10% in the converter, so that the quantity of steel produced will be about 12 to 14 of the metal charged. It is important, therefore, to remember that the amount of phosphorus in the cupola charge will remain in the steel, and thus has a proportionately increased percentage. A side-blown converter should be capable of converting a charge and be ready to receive the next charge every half hour, and sixteen or more blows may be expected in an average day's work.

In order to obtain the most satisfactory results, the charges made in the cupola should be as regular as possible in composition, and the cupola should be of such a size as to maintain regularity in the charge of fluid metal to the converter. The lining of the converter should, of course, be brought to a white heat, but even so it is important that the metal teemed into it from the cupola should be as hot as possible, particularly for the first blow, and in order that a similar quantity of metal may be converted at each blow, each charge should be weighed or measured. This is important, because differences in the level of metal in relation to the tuyères affect the operation. The capacity of a converter will of course, vary according to the condition of the lining, and modifications in the quantity of fluid metal charged will be necessary from time to time.

When the converter receives its charge of fluid metal it should be tilted in such a way that the blast can be turned on and directed down on the metal. The silicon and manganese oxidise rapidly from the beginning, and the carbon very slowly at first but gathering speed as the operation proceeds. As soon as a bluish-purple carbon monoxide flame is distinguishable at the nose the converter should be tilted to reduce the intensity of the air on the metal. In this way some of the air can be used for mixing with the carbon monoxide above the metal, and burning it to carbon dioxide with the object of increasing the heat of the charge. Some operators prefer to operate the blast valve and reduce or increase the air supply to control the reaction : almost invariably, however, the converter is tilted slightly to increase the heat in the converter, and when the effect on the metal is required to be maintained additional pressure of blast is applied.

In general practice the blow is allowed to continue until the carbon flame shortens and appears to be in front of the converter mouth. At this stage practically the whole of the carbon is removed—it being reduced to about 0·04%,—the blast shut off, and the converter partly turned down. In this position either ferro-silicon or ferro-manganese is charged to give the steel the required carbon content. Usually the alloy is heated to red heat before being charged, and the converter again tilted and the blast turned on for a few minutes to thoroughly mix the charge. The molten metal has been in intimate contact with oxygen from the commencement of the blow, and even when the oxidisable constituents in the charge have been removed there is still an excess of oxide of iron dissolved in the metal. The addition of ferro-silicon or ferro-manganese assists in decomposing much of this oxide of iron, forming oxide of silicon or oxide of manganese, which passes into the slag. Thus, in addition to giving the required carbon constituent, these alloys assist in cleaning the metal, but a considerable amount of dissolved oxygen is still left in the charge. Well-heated ladles should be ready to receive each charge, and in order to release some of this oxygen a small amount of aluminium should be thrown into the ladle.

Of the alloys added to the steel after conversion, ferro-manganese is the more common. The standard grade contains from 75 to 82% manganese and about 6 to 7% carbon. The silicon varies, and usually ranges from 0·5 to 1·5%, with low percentages of phosphorus and sulphur. The 6 to 7% carbon present enables the amount of ferro-manganese required to recarburise the steel to the desired carbon content to be readily calculated. Ferro-silicon is more particularly used for removing oxygen, and is known as a "killing" agent. It is generally used in conjunction with ferro-manganese. There are many grades, the silicon content varying from about 10% to over 90% ; the grade more commonly used, however, contains about 50% silicon. Ferro-silicons containing from 30 to 65% silicon disintegrate readily, and emit poisonous fumes on exposure to moist air ; on this account they are classed as dangerous chemicals. Instead of adding aluminium to ladles just previous to receiving the steel from the converter, silico-manganese may be added for the same purpose.

Some operators prefer to stop the reaction before the carbon content has been removed, the size and condition of the carbon flame emerging from the converter nose providing the means for determining the percentage of carbon remaining in the charge. It will be appreciated that considerable experience is necessary to estimate

the quantity of carbon remaining in the steel with any degree of accuracy, and even under the most expert operation the carbon content of a charge prepared in this manner can only be approximate to requirements.

With small converters it is necessary to get the metal away quickly, as they have a tendency to blow cold metal. This tendency can be overcome somewhat by increasing the silicon content in the charge, but greater control of the blast and movement of the converter will help to give hot metal. Converter steel cannot be too hot, as in that condition it can be relieved of much of the oxygen absorbed in the process, and, in addition, it will take intricate shapes better.

The Stock oil-fired converter differs from the ordinary side-blown converter in that it is used as a melting furnace as well as a converter. It is lined with silicious materials, and the charge must be as free from phosphorus and sulphur as possible ; thus, hematite will form the basis. In this type of apparatus the converter is moved into a horizontal position, and oil and blast turned on to heat the lining. When the lining of the furnace is at a white heat the blast is shut off and the pig and scrap charged. Resting on bars on the face of the furnace is a bar which supports the peel used for charging. The pig and scrap are loaded on the peel and pushed into the furnace, where it is arranged to protect the lining from the heat of the flame. The furnace is slightly tilted until the nose is opposite the intake to the economiser, which is an important auxiliary of this plant, and the oil and blast can then be turned on to commence the heat. The series of pipes forming the economiser becomes heated during the time of melting, and subsequently, when the converter is moved into a vertical position, the air used to provide the blow for conversion passes through these pipes ; thus, the blast is preheated actually to a temperature of about 400° C. The operation of the converter is similar to that previously described : the whole process is, however, slower than the duplex system of cupola and converter, as only four or five heats can be expected in a day's run, but it is a self-contained unit, and it possesses many advantages for foundries making many small castings, needing very hot metal.

Waldrich Square-turning Lathe.

Last month we published particulars of a patent granted to Messrs. H. A. Waldrich, of Siegen, for a square ingot turning lathe. This referred to a British patent granted to the company, but readers will doubtless remember that, in our issue of June, 1930, we gave a description of this same machine, but with additional improvements incorporated with it. A large number of these machines are in use, and the makers have improved the design continually.

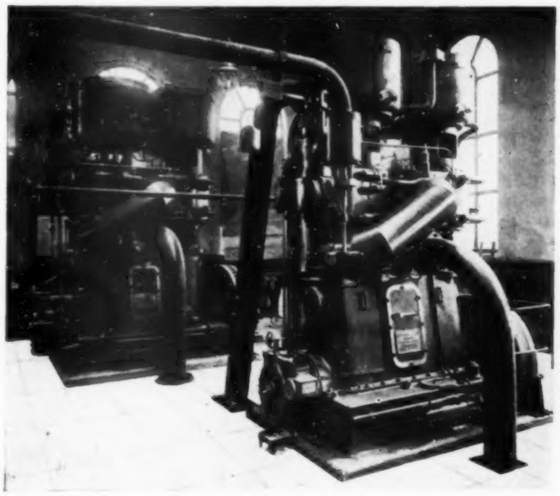
The very latest model of this machine has incorporated in it very important modifications, of which perhaps the following are the most interesting. The machine is so arranged that the tool always remains at a constant cutting angle of approximately 90° to the square ingot as it revolves, thus the tools give a much longer life. There is no template at the back of the machine, and for all sizes of square ingots with the same ratio of radius to side, there are no templates or parts to change. Furthermore, it is possible, merely by turning a handwheel while the machine is running, to make the machine turn the ingot with " fish-back " sides, straight sides, or concave sides. Loss by turning is thus reduced to a minimum. The new machine will turn also round, oval, octagonal, hexagonal, oblong-section, and other shapes of ingots with great ease. It is of interest to note that Messrs. British and Continental Traders, Ltd., Astor House, Aldwych, London, W.C. 2, are handling this machine in Great Britain and the Colonies.

Gas-oven Plant and Gas Works Auxiliaries.

The Value of Direct Steam Drive.

It is well known that in the coke-oven and the town's gas industry a considerable amount of power is required for driving pumps, fans, gas boosters, and gas compressors, as well as coal- and coke-handling equipment. Also, in both cases there is available for use an enormous amount of potential heat in the shape of waste combustion gases at a high temperature and coke breeze and dust from the screens.

Both these sources of heat are available for steam generation, while two methods can be used for driving the numerous auxiliaries—that is, electric motors with current supplied from central steam-driven generators, and direct independent steam driving, with either engines or turbines. The best method to adopt depends upon the individual conditions, and in this connection an interesting publication, " Gas Works Power Plant," has been issued by Belliss and Morcom, Ltd., of Birmingham.



" Bellis and Morcom " high-speed steam-driven gas compressors. Capacity : 300,000 cu. ft. of gas per hour, at 15 lbs. per sq. in. Automatic " start-up " and " shut-down " for day and night running

For the large units in gas works and coke-oven plant, especially gas boosters and compressors, it is in many cases the best proposition to drive direct by high-speed steam engines, with utilisation of the heat in the exhaust, a much more economical proposition than generating all the power in one central power plant, with the consequent losses due to the double conversion from mechanical to electrical energy and back again, and loss of latent heat in connection with condensing steam engines or turbines.

The main point in connection with gas works, as well as coke-oven plant, is reliability, and in this connection " Belliss " sets have always been well known. Thus, some of the firm's high-speed engines have run continuously, day and night, for over three years, and it is not unusual for engines of this type to be locked up every evening and left running until next morning. Typical is an installation of two vertical high-speed, steam-driven gas compressors with a normal duty of 300,000 cub. ft. of gas per hour, at 18 lb. per sq. in. pressure, at the Windsor Street Works of the Birmingham Corporation Gas Department. These machines run day and night, and are also arranged to start up and shut down, or alter in speed automatically, and as they often have to stand for long periods, the steam cylinders are specially steam-jacketed to avoid condensation and possible damage on starting-up suddenly.

Sand-Blast Abrasives

By William Ashcroft

Steel grit and shot are now being increasingly employed for foundry purposes, because they give long life before pulverising, and cause little dust.

THE application of sand-blast equipment to the cleaning of metal surfaces, particularly castings, received an impetus about the year 1895, when experiments indicated that compressed air applied to a flexible gas jet was the best method of projecting a stream of abrasive against the work to be cleaned. This type of equipment is now being increasingly used for preparing the surface of metals for electrolytic baths and for enamelling as well as for the cleaning of castings. Formerly sand was invariably employed as the abrasive and its use increased rapidly. Disadvantages in the use of this abrasive directed attention to the possibilities of other materials, and in some instances alundum was used, but the application of steel grit or shot for this purpose has been so successful that this form of abrasive is rapidly displacing sand. Considerable difference of opinion, however, still prevails as to which is the best form of abrasive to use with sand-blast equipment.

Sand possesses certain advantages. It is not only cheap, but for certain classes of work it produces a dull satin finish, which gives the articles a highly desirable appearance. It is readily graded in size of grains to provide coarse or fine sand, according to the requirements of the work, and as long as all clay has been removed and the sand is kept dry, there is no difficulty in discharging it from a nozzle, nor do difficulties arise in its storage. The sand may be used over and over again, but, in use, some of the grains are pulverised and cease to be of value. In order to remove the pulverised sand some form of dust separator is an integral part of sand-blast equipment, and precautions must be taken to protect the operator from the harmful effects arising as a result of breathing air laden with silica dust. The loss of usable sand from this cause is very considerable, and must be made good at frequent intervals, to ensure the plant operating with as few interruptions as possible.

Steel grit and shot are now being increasingly employed because they fulfil the purpose at least as well as sand, can be used for a much longer period without pulverising, and because the dust resulting is almost negligible. These abrasives will operate in the regular sand-blast equipment without any change of any kind, but because of the higher specific gravity of the steel grit the air pressure should be raised. In practice it is found that, as a result of the low generation of dust, the dust-suction appliances can, in most cases, be throttled, while the reduction of the dust nuisance has a considerable effect on the amount of work the operator can perform. Actually, the larger output in a given time as a result of using steel grit makes it possible to either lower the time unit per piece or batch, or shorten the running time of the sand-blast equipment in the working period.

The appearance of the work cleaned with steel grit or shot is particularly good, and parts difficult to clean with sand are more readily brought to the desired condition, and although a coating of dust clings to the surfaces, it is easily removed by turning the air blast on the work. With sand abrasive, on the other hand, the fine silica dust adheres more firmly, and when work is to be plated it is necessary to dip it in acid to remove the silica, otherwise the plated surface will have a poor finish. The cleaner surface produced by steel grit or shot dispenses with the need for an acid bath in such instances, and, in the case of japanned, lacquered, or enamelled work, the cleaner surface facilitates the operation.

Although the initial cost of steel shot or grit is relatively high, it is very questionable indeed whether sand is actually cheaper in service, especially in view of the dust nuisance associated with it. Experiments have been carried out with silica sand, alundum, and commercial steel grit with the object of testing the relative service obtainable from these abrasives. In each case 200 lb. of abrasive was used, and the tests were carried out under similar conditions on similar articles. As a result of these tests, it was found that the 200 lb. of silica sand was exhausted after cleaning 4,700 of these articles, the alundum at 20,000, while the steel grit ran in excess of 80,000. The experiments indicated that 1 ton of steel grit was equal to 20 tons of silica, which would more than compensate for the difference in cost. Apart from this, however, the shorter life of sand necessitates storing in larger quantities, with resultant high transportation, drying, and storage costs. The relatively small quantities of steel grit or shot necessary can be stored in the direct vicinity of the machines in special bins from which the operator, after noting the amount used up each day, can replenish his machine. It is, of course, necessary to protect the material from moisture or it will rust and form into lumps. No drying is necessary as with sand, since steel grit or shot is not hygroscopic.

Separation of the dross resulting during work with steel grit or shot is effected without the use of special appliances, solely by the action of the exhausters normally associated with sand-blast equipment. The grit retains its sharp edges and clean appearance, even after long-continued use, and will not rust as long as the compressed-air line is properly supervised. The use of these artificial abrasives effects a considerable saving in the iron nozzles used to project the stream on the work. Tests have shown that the wear on these nozzles is from one-sixth to one-eighth of that with natural sand. The greater specific weight of the artificial abrasive over natural sands gives a better efficiency as a result of increased utilisation of the energy of the compressed air.

Steel grit or shot is made in several grades, varying in size from a pin-head to a small pea. They are made of chilled cast iron, the grit usually consisting of chilled shot crushed to give the sharp-edged material.

In spite of the advantages of steel grit and shot many prefer to use sand, and there is a steady demand for special grades for a wide range of sand-blast uses. Silica or quartz sands are more commonly used: these are available in about four grades, determined by a sieve mesh varying between 35 and 4. Opinions differ as to the relative merits of sharp, angular grains and rounded grains. Advocates of sharp grain claim faster cutting, while others claim smoother work and longer life from rounded grain, which enables it to be re-used more often with less formation of dust.

All quartz grains have about the same hardness. There is, however, considerable difference in the ability to resist crushing and shattering, but no method of actually testing this property, other than actual use, has been developed. These sands contain silt or clay, which, adhering to the quartz grains, can only be removed by washing. Varying amounts of carbonaceous matter may also be present, which would break up and pass through the sieves with the finished sand. For proper use, however, the sand must be perfectly dry, otherwise it tends to choke the sand-blast equipment. The presence of clay or other foreign matter may cause the sand to absorb moisture, and in this way cause trouble in its use. This foreign matter also increases the amount of dust formed when the sand is used, but clay dust is much less injurious than silica dust.

The Value of Nitriding

Wear by abrasion is one of the most costly sources of loss in modern industry, and all processes that effect a reduction in wear should be developed with the object of increasing their application.

THE invention of the process of nitriding by Dr. Adolph Fry opened up a very interesting and important field, and both metallurgists and engineers have taken advantage of its applications. Particularly is this a trait of our American cousins, who are not so conservative in their attitude to new developments as we are in England. The possibilities of the process were appreciated by the American Society of Steel Treating, when in September, 1929, papers were presented at a symposium on the subject at the annual convention. Even at that time nitriding had created a tremendous interest in the United States. This was clearly indicated by the number of papers on the subject presented at that convention. Dr. Fry attended, and gave a short resume of the various problems connected with his process. He stressed particularly the disadvantages resulting from the employment of high temperatures (550°—650° C.), the necessity of eliminating all machining stresses and stresses caused by heat-treatment if freedom from distortion during nitriding is desired, and he referred to some very salient points, which had been demonstrated by different investigators, and which included the following :—

1. The nitriding process, if handled properly, gives surface hardness with practically no distortion.

2. The physical properties of the core material are not changed by nitriding.

3. The hardness and wear resistance are higher than those of any other steel-treating process.

4. The hardness is not injured by tempering temperatures even above 950° F. (510° C.).

5. Nitrided parts are free of internal stresses, and therefore free from ageing effects.

6. Nitrided parts are rust-resisting to a certain extent.

7. The process may be adapted to various applications having varying requirements. This is done by selecting a nitriding steel of the proper composition for each purpose.

8. The best results are obtained by quenching and tempering the raw material, and then carrying out the machining and nitriding operations.

9. Various nitriding agents have been tested in the past several years, not only ammonia gas, but also cyanides, sulphocyanates, and so on. Some of them, such as sodium nitrates, fail to give surface hardness, whereas others, such as sodium potassium cyanide, gave good surface hardness but were less easy to handle than ammonia gas.

10. The use of a fan causes circulation, and will help to give uniform nitriding.

11. To obtain the best results, it is necessary to avoid surface oxidation : foreign metals touching the steel, such as nickel not yet saturated with nitrogen, and foreign substances in the ammonia, such as oil and water.

These salient points were reviewed in the light of modern practice by Mr. M. A. Grossman, vice-president of the Republic Research Corporation, in a paper presented to the American Iron and Steel Institute recently. The author dealt with the points in their order as summarised by Dr. Fry. In regard to distortion, he stated, if pieces are supported properly while at the nitriding temperature, except in certain cases to which reference is made later, no distortion occurs. The term "distortion" is here restricted to its proper sense of change of shape, and usually no change of shape is experienced in nitriding. There is, however, a slight increase in size, commonly termed "growth." The amount of growth is of the order of 0·001 in. to 0·002 in. per inch at usual nitriding temperatures, which is usually negligible, but it is greater when the nitriding temperature is higher. This is an additional reason for avoiding high nitriding temperatures in the initial stages. This growth may also cause distortion; thus, for instance, if a thin sheet is nitrided on one side only, the other side being protected (as by tinning), the unprotected side will nitride and grow and the sheet will tend to curl. Similarly, pieces of complicated shape with marked differences in cross-section may suffer distortion.

Present practice in nitriding steels is to give the hot-rolled steel a preliminary heat-treatment, consisting of quenching or air-cooling from above the critical temperature, say, from 1,700° to 1,750° F. (925° to 950° C.), and then to reheat to some temperature above the temperature of nitriding. Obviously, if the reheating or tempering is done at 1,300° F., a subsequent nitriding at 950° F. is not likely to have any further effect on the core properties. However, a useful second nitriding stage at 1,150° to 1,200° F. is often practised with advantage after nitriding at 950° F., in which case the preliminary tempering before nitriding should be governed accordingly.

The assertion in regard to hardness and wear resistance, the author considers to be fully justified, and he states that modern practice proves that hardness is not injured by tempering temperatures even above 950° F. He assumed this referred to the hardness at room temperature after cooling down from the tempering temperature. The statement holds for temperatures of at least several hundred degrees above the nitriding temperature of 950° F. The time at such elevated temperature must not, however, be extended inordinately. It should be emphasised that this refers only to the properties of the hardened case, when surface effects are carefully avoided. In regard to ageing effects, it is perhaps proper to mention temper brittleness, which was sometimes, but not always, encountered when nickel was used in the alloy. This brittleness, which develops on cooling from nitriding, is a phenomenon whose nature is not yet well understood, and although it is often found when nickel is present, it does not necessarily accompany it. To take full advantage of the rust resistance, which is often present, it is advisable to use the original nitrided surface wherever possible, and to do no grinding after nitriding.

In dealing with the varied applications of the process, the author stated that Dr. Fry evidently considered hardness and depth of nitrided case, whereas the present search for improvement is more concerned with the core. In most applications a case-hardness well above 800 Vickers is obtained, and is adequate. That is, the steels which have been adopted as tentative standards are of such composition that they give hardness of at least 800 to 900 Vickers. If greater depth of case is desired, it is secured by extending the time of nitriding or by using a duplex cycle

with a high nitriding temperature toward the end of the run.

The quenching, or sometimes air-cooling, from a temperature well above the critical point—*i.e.*, from, say, 1,725° F. —gives a uniform structure, free from large areas of ferrite. As a result, the subsequent nitriding is much more uniform and tough. At the present time all nitriding is done with ammonia. A suggestion has been made regarding the use of molten cyanides, which give a hard but extremely thin case. Circulating ammonia gas is the almost universal present-day nitriding agent, and the use of a fan was found to overcome the lack of uniformity in different pieces in the same nitriding box.

In regard to surface conditions to be avoided, it has been shown that surface oxidation, especially decarburisation, results in a very brittle (almost friable) case. This matter of surface oxidation is one of the most serious causes of failures encountered in present-day nitriding practice. The statement has been made that the presence of decarburised, oxidised surfaces before nitriding leads to more failures of nitrided parts than any other single cause. These defective cases are very brittle, and result in early spalling of the piece in service. Foreign metals susceptible of nitriding sometimes have an unexpected effect in retarding nitriding, and this is equally true of the nitriding containers themselves. Foreign materials in the ammonia, such as benzol, have at times been used in an attempt to minimise decarburisation.

It is natural that in the development of the process a number of difficulties would arise, and in overcoming these considerable headway would be made in regard to the wider practical application of the process. It was found, for instance, that with many of the metal containers used as nitriding pots, the depth of case obtained on the pieces being hardened decreased with the continued use of the nitriding container over long periods of time. If the container was replaced, the case obtained was equal in depth to that obtained from early use of the original container. Thus, it is concluded that a change occurs on the inside surface of the container which decreases the efficiency of the ammonia in nitriding. This was a serious obstacle, and the data at hand indicate that only two successful containers have been developed up to the present time. One of these, an early development, consisted in using as a container a nickel-chromium alloy containing 25 per cent. chromium and 20 per cent. nickel. A more recent development uses a container enamelled on the inside. These enamelled containers seem highly promising, one of them having been in service already for 2,700 nitriding hours.

For protecting certain parts against nitriding, a tin coating still appears to be best. Pieces may be tinned hot, an alloy of tin and lead in equal proportions being sometimes used, or the surface may be protected with a coating of tin electrolytically. Waterglass mixtures also give some protection.

Although much progress has been made in widening the applications of the process, it still has many limitations. Thus, in articles like sand-spray nozzles, nitrided steel has failed to give satisfaction on account of the comparatively shallow depth of case. Even with extreme hardness, the surface case is soon abraded away, then the unhardened material below offers little resistance. In the presence of mineral acids nitrided surfaces offer very little resistance, and such applications hold very little promise. Furthermore, in neutral solutions there should be no foreign metals, such as brass, in contact, otherwise corrosion is very rapid. In alkaline solutions, however, nitrided surfaces are satisfactorily resistant.

Where there is heavy or repeated impact, such as in clash gears or impact gears, commonly used nitriding steels do not have sufficient core strength. The case is soon cracked, and the article is no longer useful.

Co-ordinating Rules and Specifications for Boilers and Pump Tests.

THE recommendation of the Imperial Conference regarding the co-ordination of all codes and standard specifications issued within the British Empire is having a most beneficial effect. Particularly is this the case in connection with Australian and British standards in the engineering field. A notable example is the Australian Boiler Code, recently issued, which is under review by the Standards Association of Australia, and has been forwarded to the Home Committee for comment with a view to ultimate co-ordination in so far as may be practicable.

The British Engineering Standards Association, as the result of a fully representative conference of boiler makers and users, classification societies, insurance companies, Government departments, and others interested, has nominated a strong executive committee to prepare a set of British Standard Boiler Rules and Specifications.

The conference, which was largely attended, was held at the Institution of Mechanical Engineers, under the chairmanship of Mr. William Reavell (the chairman of the Mechanical Industry Committee), and Rear-Admiral Sir Robert Dixon, K.C.B., has accepted the chairmanship of this large and influential Committee.

Moreover, the boiler-makers of the country have come together and formed a permanent Makers Panel, under the chairmanship of Lieut.-Colonel E. Kitson Clark (the president of the Institution of Mechanical Engineers), and have nominated some twelve of their number on to the above Executive Committee, to represent the whole of the boiler-makers' interests of the country. This collaboration enables the Executive Committee to be on a fully representative basis, so important to the success of the work. Should occasion arise, the representatives of the boiler-makers on the Executive Committee will be at liberty, through this Makers Panel, to consult all the manufacturing interests in order to bring to the Executive Committee the consensus of opinion of the producing interests on any point at issue.

The Committee is also assured of the fullest support of the Engineering Insurance Companies, and it is probable that, at their own request, they will be entrusted with the preliminary work of co-ordinating certain portions of the proposed rules, which, from their long experience and very intimate knowledge, they are in a peculiarly good position to undertake. It is interesting to note that the boiler-makers have already broadly considered the question as to the best method of dividing up the work, which will be along the lines of the existing divisions in industry.

The Australian Committee has already signified its desire for cordial co-operation in the work, and it is confidently hoped that ultimately rules governing the design and construction, etc., of boilers, will be arrived at, applicable to the whole of the British Empire.

The Mechanical Industry Committee of the Association also received a unanimous recommendation from a fully representative conference of pump users and makers, and have authorised the constitution of a Pump Test Committee to co-operate with a similar Committee in Australia, which has recently issued a draft Australian Pump Test Code.

In this case Mr. Richard Allen, C.B.E., of Bedford, has accepted the chairmanship of the Committee, and will guide this important piece of work of codifying requirements for conducting guarantee tests of pump performance and efficiencies, and particularly of assisting British pump makers in their home and export trade. In this case also there was a most decided desire on the part of all concerned to adopt the Australian draft as a basis and take as much as possible from the Australian proposals without alteration. At the same time, should it appear desirable from the British point of view to introduce modifications, then, naturally, the Australian Committee will give British representations careful consideration to bring British and Australian practice as far as practicable into harmony.

Recent Developments in Tools and Equipment

A NEW COAL-DRYING PROCESS.

It is now well known that coal required for coke making necessitates preparation and cleaning, so that it can be used more effectively. The coal is crushed to a size varying from approximately 1½ in. to dust, and is subsequently cleaned by either wet or dry processes. It is now generally appreciated that wet cleaning is more efficient than dry cleaning. The cleaning process has for its object the removal of impurities, which facilitates the production of good clean coke, with low ash and sulphur content. In addition to the removal of shale and slate, the washing process, which is more generally employed, has the effect of reducing the sulphur content 30 to 40%, and the free dirt to a minimum of 1·5 to 2·0%, which reduces the ash content about 50%. Furthermore, some coals contain small percentages of common salt, which, in conjunction with moisture, has a corrosive influence on the oven walls at the carbonising temperature, and washing practically removes this constituent.

The coal, after washing and partial draining, may contain from 15 to 20% of water, and the removal of this moisture is an important problem, and one which is a fruitful cause of complaint. In order to facilitate the carbonising process, methods of drying the coal are now adopted, and the advantages resulting are very considerable; thus, for instance, the removal of water in an external dryer is more efficiently done than in the oven, and the nett fuel consumption is reduced; coking time is economised by 20 mins. to 1 hour for every 1% of moisture removed, which increases the coking capacity of the ovens and the benzol, gas, and tar yields; it lessens the risk of spoiling the brick, and reduces the cooling of the oven walls; it reduces the amount of liquor to be handled, evaporated, and to be disposed of as a troublesome effluent.

Various types of machines developed for the purpose of drying coal depend upon centrifugalisation as the means of throwing the water out, others are operated by heat, as in the double-shell, horizontally-rotating type of dryer, but a new process, which has been developed by the Brightside Foundry and Engineering Co., Ltd., is operated by heat on a different principle, and shows a considerable advance on present methods of carbonising coal for coke making.

As a result of high thermal efficiencies obtained during the first few weeks this new Universal dryer was in regular commission, a series of comprehensive and searching tests have been made by Mr. R. A. Mott, M.Sc., F.I.C., of the Department of Fuel Technology. These tests extended for a period of over a week, and the results are contained in a report issued by Mr. Mott. The tests were carried out at the Barrow Collieries, where the dryer and the burner setting occupy a ground space of only 16 ft. by 14 ft., with a head room of 24 ft. 6 in., for a capacity of 42 tons per hour and a water removal of 5·5%. The shape of the dryer requires the use of a tall, narrow feed hopper, which increases the head room by 10 ft. The double-shell type horizontal rotating dryer, for a capacity of 45 tons per hour, requires a building 93 ft. by 20 ft. ground space, with a head room of 22 ft. to the top of the feed hopper. The new dryer, by comparison, is erected in a building 27 ft. 6 in. by 26 ft. 6 in. ground area, a platform being erected about 19 ft. above the floor level, to carry the fan and waste gas-discharge conduits.

This new dryer, which is made entirely of cast iron, is vertical, and uses a gravity feed from section to section. In each chamber of the dryer there is a six-sectioned spider. The spiders in different sections are staggered, and revolve in opposite directions in adjacent sections. A 40–45 tons per hour unit only requires a ground space of 5 ft. by 13 ft. 6 in., and a complete installation with coke-oven gas firing is installed in a building 34 ft. 6 in. to the top of the feed hopper. The gravity feed is so efficient that less than 2 h.p. is required to pass 40–45 tons of coal through the dryer itself. The drive for the dryer consists of an endless chain passing over toothed wheels, by means of which the six-sectioned spiders or retarders in each section of the dryer are rotated. The speed of rotation is only 1·26 r.p.m. for a capacity of 40–45 tons per hour; thus the mechanical wear is negligible. The dryer sections are built of cast iron with a special heat-resisting mixture for the bottom section, to which the hottest gases are admitted. As the average temperature of the hot gases entering is 420° C. at the hottest point, replacements of sections through heat distortion are unlikely. The coal is only in the dryer about 4½ mins., and follows an almost vertical path: there is, therefore, little likelihood of building-up in the dryer. Inspection plates, however, are fitted to each section, and any caked coal can easily be removed.

The dryer takes less than 1 hour to heat up from cold, but the working heat can be attained much quicker if the shut-down period has been only 8 hours. Indeed, the heat of the dryer can be maintained overnight by suitable pilot lights, burning under natural draught, and the dryer can be fired by gaseous, liquid, or solid fuel.

With suitable means of maintaining the feed hopper full, and of removing the dried coal, the only supervision necessary is to maintain suitable temperatures in the dryer. By the use of thermocouples connected to a single indicator, the temperature control is comparatively simple. It is usual to arrange that the temperatures in the two ends of one section of the dryer are maintained approximately the same, to ensure uniform upward expansion of the dryer and to maintain gas-tightness at the expansion joints. Each half length of the dryer is controlled by a separate main gas cock, so that equalisation of temperature at the two ends is easily attained.

The report states that the dryer was under observation for a period of one week, during which time the dryer was worked for about 12–16 hours per day. Whilst under observation there was only one enforced shut-down of the plant, of 8 mins. duration, to replace a broken link in the dried-coal elevator. The slack fed to the dryer had only been drained for a period of about 4 hours, and contained a large proportion of slurry. This is indicated by the extremely large percentage of the feed which passed a ¼-in. screen—namely, 50%—an abnormally high figure. The de-watering of such a material in a centrifuge would have presented great difficulty, owing to the large amount of material which would pass through the screens.

The size analyses of the average feed and discharge during a 7-hour period were identical, showing that no disintegration of the coal had occurred, and that there was no loss of dust with the discharged waste gases. An examination of the volatile matter content of hourly samples of the feed and discharge showed that there was no loss of volatile matter in passing through the dryer.

This is to be expected, since the coal never rose in temperature above 65° C., and was only in the dryer for a period of 4½ mins. The coking properties of the coal were also unaltered. This was tested by charging two ovens with undried coal and two ovens with dried coal. Samples of 4–5 cwt. of coke from each oven were sized and subjected to shatter-testing. The average shatter indices of the cokes made from the undried and dried coals were *identical*.

Thus, heat-drying under the conditions used at Barrow

Collieries has no adverse effect on the quality of coal. When drying coal by heat so as to leave, say, 8% of moisture in the dried coal, the residual moisture, besides ensuring that no loss of volatile matter can occur, prevents any dust from being carried along with the combustion gases, and a cyclone for dust settling is unnecessary. It is only when the dryer is being started up or stopped that particles of coal which have caked on the spider retarders are dried sufficiently to be removed with the waste gases. The discharge from the fan is quite white.

The dryer can, of course, be used to remove a greater amount of water by reducing the speed of the spider retarders. For a given heat input, and a feed reduced by 50%, the moisture removal would be doubled.

The results of the tests disclosed in this report have satisfied Mr. Mott that the dryer is likely to be of great use to the coking industry. With its large capacity, high thermal efficiency, low-power consumption, low ground-space requirements, low upkeep costs, simplicity in control, and reliability, which have prevented the widespread adoption of other de-watering and drying appliances capable of giving coal of less than 10% moisture content. He is, further, of the opinion that this dryer will be found applicable to the drying of coal for pulverised fuel firing, and also for drying the other commodities for which heat dryers of less satisfactory design have been used in the past.

A NEW CENTRIFUGAL CASTING MACHINE.

Messrs. Craven Brothers (Manchester), Ltd., Reddish, Stockport, the machine-tool engineers, have for some time been manufacturing centrifugal castings for gear-wheels, rings, etc., the outcome of which has been the development of an improved model centrifugal casting machine for the production of such castings. The process is suitable for both ferrous and non-ferrous metals, but particularly for bronze gear blanks, rings, etc., up to 3 ft. in diameter.

The machine consists of a horizontal rotating table J, bolted to a suitable spindle M, which is carried in roller bearings, and revolves at definite speeds, these speeds being variable to suit conditions for any given diameter of ring which has to be cast. The spindle M is securely bolted to the table, and has a washer of suitable insulating material K, interposed between the joint faces. This washer prevents any excess heat from travelling to the bearings via the spindle.

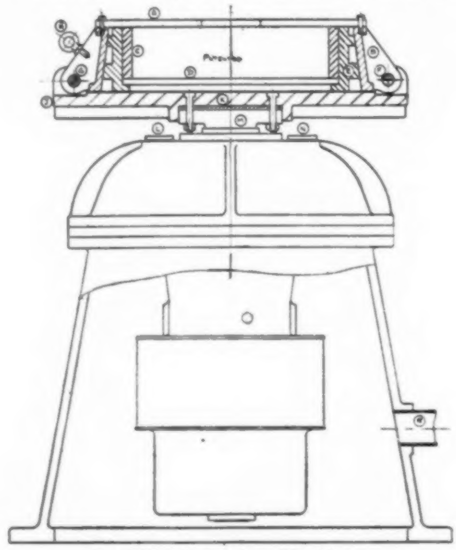
The revolving unit is carried in a heavy cast-iron housing, designed to damp-out vibration and to completely enclose all bearings, etc. The motor P, which has an integral flange, is bolted securely to the underside of the housing, and drives direct to the spindle by means of a flexible coupling, which prevents any whirling due to mal-alignment or expansion of the shafts. The cast-iron housing, with motor *in situ*, is bolted to a hollow cast-iron base, thus completely protecting every moving part from the dust which is invariably present in a foundry.

Careful attention has been paid to the cooling of the table and spindle, which plays an important part both in obtaining uniform casting results and in the life of the revolving members. This cooling is done by air, which presents the cleanest and cheapest method, and is efficient.

The motor P, which is of the pipe-ventilated type, draws in air through the inlet pipe R. This air is circulated round the motor windings, and discharged into the inside of the spindle housing, where it is picked up by a fan mounted on the spindle, and blown against all faces which require cooling. Finally, it is discharged through the outlet holes L and N, and impinges on the underside of the table J. The table is equipped with several spiral vanes, which are so shaped that they throw out the waste air from the centre to the periphery, thus exhausting the air from the housing, and at the same time cooling the table. It can be seen from this description that a supply of cold air is continually circulating through the machine, and the result is claimed to be most satisfactory. Great care has been taken to provide means of preventing any dirt or dust from being carried in with the air at all inlet and outlet points, and the pipe R is usually carried to the outside air as an additional precaution.

The mould, which has been arranged for expeditious handling, functions in the following manner :—

A hinged casing B, which is conical in its bore, is secured to the table by means of two substantial hinge-pins, diametrically opposed. A locating ring E, which registers in the conical bore of the casing B, and carries a metal mould ring C and a bottom plate D, and the necessary cores (not shown) comprises the mould proper. A top plate A, which is permanently fixed in position, serves to hold the cores down and prevent them floating upwards. By removing the pin G, which is arranged for easy withdrawal, and lifting the casing B, by means of the eyebolt H, the conical locating ring can be removed with the casting, etc., inside it, by sliding it from the table on to the floor.



Centrifugal Casting Machine.

To reload the machine, it is necessary to push another locating ring into position, complete, ready to be cast.

It is evident from this description that, by using two of these locating rings, continuous production can be obtained, as one ring can be loaded while the other is in the machine, and vice versa. Another important point is that all crane service is eliminated, as one man can easily lift the casing by putting a bar through the eyebolt H. While the lubricating to all moving parts is carried out by means of a grease gun, which forces grease under pressure to all bearings, etc.

The electrical equipment on this machine consists of one 7½ h.p. variable-speed motor, of the vertical spindle type. The controller gives a definite series of speeds, in nineteen equal steps. The circuit breaker is arranged for operation to be controlled by a small switch, which, when operated, closes the circuit breaker and energises the shunt-field to enable light dynamic braking to be applied when the control handle is brought to the " off " position.

The machine can be arranged for semi-automatic control of the push-button type if desired, by which the motor can be run up to any speed required by keeping the " start " button depressed, and when the button is released the speed will be automatically held. On pressing the " Stop " button the motor runs down through all the speeds, thus bringing the controller into position for the next sequence of operations. Control gear can also be supplied, in which any speed of the motor is held for a definite time, after which it will automatically drop to the next speed and continue to run at that speed for a given time. This control can be arranged to give four such steps in the speed, ranging in time from 1 sec. to 2 mins.

The Influence of High-frequency Vibrations upon the Heat-treatment of Materials

By D. R. Lewis, M.A., Ph.D.

Reduction in time, greater skin hardness, and enhanced general properties, are claimed to be obtainable for nitrogen-hardened materials under the influence of high-frequency vibrations.

AUTOMOBILE and aeronautical construction has reached such a stage of development—the engines of the light car and aeroplane in particular accomplish, without effort, the high speeds now demanded, and triumphantly undergo endurance tests such as (only a very few years ago) would have been undertaken by the much more expensive and higher-powered models—that it has been found necessary not only to use in their construction the very best materials, but to have those materials in such condition as they will give the best service. It will be agreed that it can be of little use to employ an expensive alloy steel for, say, the valves of an internal-combustion engine unless the material is put into the best possible condition for resisting heat before the valves are put into service.

These considerations and, indeed, many others, have led to much research being undertaken both in this country and on the continent; and an interesting account of a series of researches and tests, having for their object the improvement of the characteristics of the various steels used in the automobile and aeroplane industry, has recently appeared in a French technical journal, *Le Genie Civil.*

Objects of Heat-treatment.

In the ordinary way, heat-treatment is resorted to in order either to increase the surface hardness, ductility, or toughness of a steel; and all things being equal (temperature, length of heating, etc.), certain reactions may be expected, and actually do take place. All, however, at fairly high temperatures, depending, of course, upon the carbon content and other elements present in the steel.

It has been found possible, for instance, to produce certain reactions at comparatively low temperatures by the nitrogen process of steel hardening, a process which has attracted much attention in both industrial and scientific circles. It is this heat-treatment (if it may be so called) combined with a method of subjecting the steel to a series of high-frequency electrical vibrations whilst under the influence of ammonia gas, that has been the subject of the research of which mention has already been made.

Nitrogen Hardening.

Nitrogen hardening has many outstanding advantages. The skin of the treated material is very much harder than is common with a steel casehardened in the usual way. This hardness is obtained without any distortion or change of dimensions, such as is customary when hardening by quenching and tempering is adopted.

The process, however, has several disadvantages, *inter alia*, the operation is unduly lengthy, occupying some three to four days, and the hardened surface layer is very brittle.

It would appear, however, from experiments which have been made, and of which two examples of each type are given later, that these difficulties are likely to be overcome, and that, in time, one may expect the valves, gear-wheels, and other automobile components will be heat-treated by this method, as is already the case with some of the components in which the resistance to shock is not so vital.

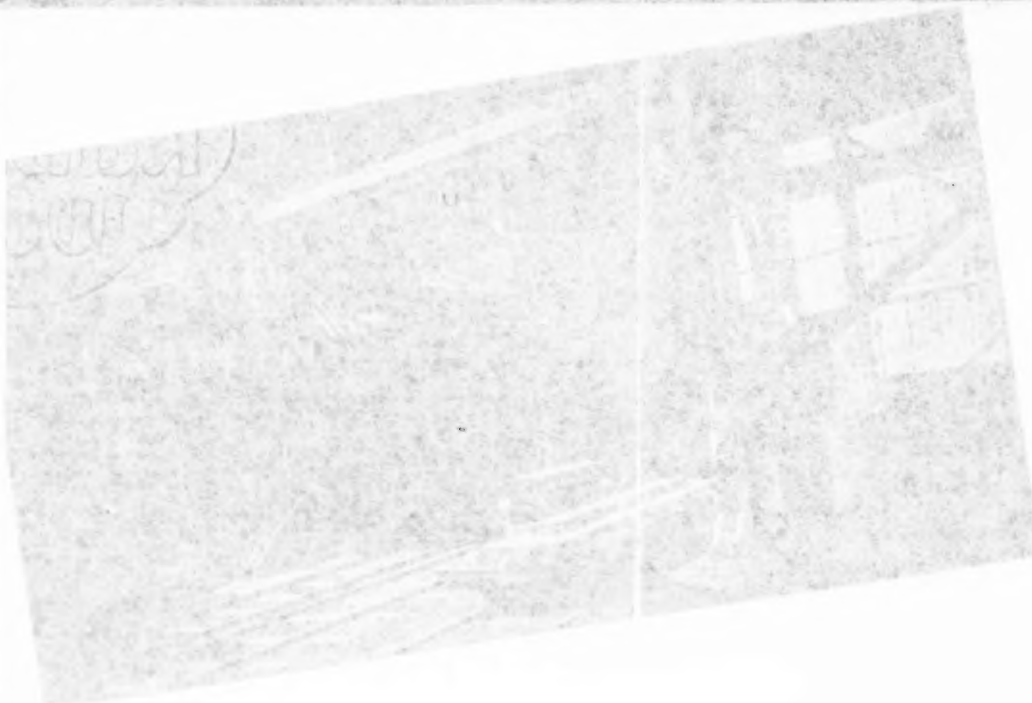
Use in the Tool Room.—This method of heat-treatment of steel is, in addition, likely to become an important ally of the tool-room superintendent when properly understood and developed. For next to corrosion, abrasion is probably the most costly source of loss in industry. It has been found that milling cutters and similar cutting tools, after undergoing this treatment, in addition to the customary method of heat-treatment, have a prolonged life between grinds.

Experimental Results.

Investigations were conducted in order to show (*a*) the action of the high-frequency vibrations on the hardness of steels of diverse chemical analyses; (*b*) to find out what effect the vibrations have on the diffusion of certain elements.

Test-pieces of the material to be treated were inserted in the circuit of an electro-magnetic oscillator, being fastened by a "U" bolt to a steel plate, but no details were given of the strength, voltage, or number of the vibrations, etc., of the electrical currents used, and, so far as that omission is important or not, so far may experiments be deemed incomplete.

(*Continued on page 126b.*)



The Battery of [illegible] and mould drying ovens at upper left is installed in the foundry of Messrs. [illegible] Brothers, Ltd., Sheffield, who use "August" equipment for this purpose exclusively. The centre picture shows the "August" facing-sand plant at [illegible] Ltd. [illegible] grouping of [illegible] the [illegible]

We have data available for your consideration of complete "August" installations and foundry units, [illegible] and mould drying plant, conveyor systems, [illegible] and handling schemes for [illegible] sand [illegible].

AUGUST FURNACES

Specialists IN FOUNDRY TREATMENT

THE NEW "AUGUST" [illegible] FURNACE.

This [illegible] and [illegible] furnace has been designed to [illegible] all of the [illegible] of the [illegible] furnace chamber.

The "[illegible]" type elements are [illegible] for the furnace, there being no brick [illegible] the elements and the muffle chamber. This [illegible] type element is good for long life at 1,000 [illegible] of [illegible] tempering heats are required. A [illegible] switch movement keeps the maximum temperature at about 800 [illegible] with resultant current economy.

AUGUST MUFFLE FURNACES LTD.

The [illegible] Plant shown [illegible] is the [illegible] installation at Messrs. [illegible] Ltd., Smethwick. [illegible] "Vulcan" Patent Muffle [illegible] with [illegible] [illegible] which [illegible].

[illegible] muffle and [illegible] types [illegible] annealing [illegible] treatment [illegible] We [illegible] type furnaces [illegible] heat treatment complete with charging [illegible] types of [illegible] catalogue [illegible]

MUFFLE
LIMITED
PLANT & HEAT
FURNACES

[illegible]

[illegible]

[illegible]

HALIFAX
ENGLAND

EXPERIMENT NUMBER 1.

Material.—Steel, nickel-chrome molybdenum.

Chemical Analysis.—

C.	Ni.	Cr.	Mo.	Si.	Mn.	S.	P.
0·35	3·0	5·0	1·0	0·25	0·25	0·04	0·04

Test Piece.—15 mm. diameter.

Treatment.—Subjected to high-frequency vibrations for nine hours at a temperature of 500° C. in a current of ammonia gas.

Physical Characteristics of Material.	*Before Treatment.*	
	Tensile	135 kg. per sq. mm.
	Yield	9 kg.
	Brinell figure	380
	After Treatment.	
	Tensile	—
	Yield	11·8 kg.
	Brinell figure	1033

The percentage of nitruration was 0·35 mm.

The experiment was conducted again on the same lines, but omitting the high-frequency vibrations, with the following result :—

Surface Hardness.—No alteration measurable.

Penetration.—0·01 mm.

Yield.—9 kg.

EXPERIMENT NUMBER 2.

Material.—Austenitic steel for valves.

Chemical Analysis.—

C.	Cr.	Mn.	Ni.	Mo.	Si.	Tu.	P.	S.
0·31	19·8	0·35	8·0	0·23	2·5	4·0	0·01	0·015

Test Piece.—15 mm. diameter.

Treatment.—Subjected to high-frequency vibrations for ten hours at 530° C. in a current of ammonia gas.

Physical Characteristics of Material.	*Before Treatment.*	
	Tensile	80 kg. per sq. mm.
	Brinell figure	235
	After Treatment.	
	Brinell figure on surface	1035
	Brinell figure 1 mm. below surface	570
	Brinell figure in centre	472

The same test made, but omitting the high-frequency vibrations, did not show, on examination, any difference between the surface and interior of the test-piece.

From these experiments the following deductions may be drawn :—

(*a*) A more rapid penetration if the steel is subjected to high-frequency vibrations whilst under the influence of the temperature and ammonia gas.

(*b*) A higher hardness figure.

(*c*) A definite improvement in the yield point of the test piece.

EXPERIMENT NUMBER 3.

This experiment was made in order to ascertain the influence of the high-frequency vibrations upon the diffusion and penetration of chrome into mild steel. For this purpose a mild straight carbon steel was selected, having the following analysis :—

Composition of Steel.—

C.	Mn.	Si.	S.	P.
0·1	0·25	0·25	0·03	0·03

Test Piece.—Bar 15 mm. diameter.

Treatment.—The test piece was chromium plated electrolytically and afterwards submitted to the action of the high-frequency vibrations for nine hours at a temperature of 530° C.

After treatment, a microscopic examination showed that the chrome had penetrated to a depth of 0·35 mm.

A similar examination of a test-piece chromium plated as above, but not submitted to any vibrations, did not show any penetration, the layer of chrome being simply deposited on the surface.

EXPERIMENT NUMBER 4.

In this experiment the diffusion of the carbon of a piece of cast iron was produced from the interior by the surrounding air whilst under the influence of the high-frequency vibrations.

Composition of Cast Iron.—

Combined Carbon.	Graphite.	Si.
3·10	0·229	1·40

Test Piece.—Bar 15 mm. diameter.

Treatment.—Subjected to high-frequency vibrations for ten hours at 530° C. in a current of air.

An examination of the test-piece after the experiment showed that it was covered with powdered carbon for a thickness of 0·3 mm., and the depth of the cast iron decarbonised was 0·8 mm.

All the experiments enumerated are but examples of the many which have been made. It, however, may be stated quite definitely that under the influence of the high-frequency vibrations the time of nitrogen hardening is considerably reduced, a greater skin hardness is obtained, with a corresponding increase in depth. Moreover, the general properties of the material are enhanced, notably the yield-point.

So much confidence is placed in the process that not only have notable firms in this country put in plants for the treatment of cutting tools and components, but one firm is now undertaking nitrogen hardening under the conditions described here for customers in general.

This process is one of the most interesting of the many processes which science has evolved, and is now perfecting for the benefit of industry ; and it would seem that it is only a matter of time before its employment becomes more and more general.

Surface Treatment of Aluminium and its Alloys

MUCH research has been carried out on electro-deposition to study the causes of the difficulties which are encountered and to be able to combat them. The theory of electro-deposition is still a somewhat controversial subject. Deposition may be considered to be due to (*a*) mechanical conjunction, (*b*) physical conjunction; and some metallurgists consider the former—mechanical hooking or interlocking—to be sufficient to produce deposition; while others consider physical conjunction to be the primary phenomenon to which mechanical conjunction is merely an auxiliary to adhesion.

Physical conjunction is dependent on two phenomena—cohesion and diffusion. Cohesion, the dominant phenomenon, produces intimate atomic or molecular contact of the two bodies in contact, which gives rises to the formation of alloys at the contact plane of the deposit and base metal, and to the continuation in the deposit of the crystal structure of the base metal. Diffusion, the agent which enables cohesion to operate, produces intermingling of the atoms or molecules of the two bodies.

The mechanism of adhesion is probably as follows:—Embryonic crystals of the deposited metal form and are attracted (cohere) to the atoms of the cathode metal, either on the walls of the pores or on the surface outside the pores, forming a thin primary layer of deposited metal intermixed with the metal of which the cathode consists; this layer becomes widened by diffusion. The cohesion may take place between the atoms of any solid body, whether they are of different or similar chemical elements, but the tendency in the former case to form inter-metallic compounds or solid solutions facilitates the cohesion.

The most important considerations in electro-deposition are to obtain a fast-adhering and uniform deposit. The surface conditions, properties of the base metal and deposit, respectively, and the relationship between any of the respective properties are decisive factors in obtaining these qualities.

Aluminium presents special difficulties for electro-deposition by reason of its oxide film and its high position in the Electromotive Scale, which latter fact tends either to produce deposition of a non-adherent metal layer at the start of plating and prevent the deposit proper from adhering, or to accelerate corrosion. The difficulty of the non-adherent film can be overcome by (1) coating the metal with a fast-adhering coating of a second metal (usually Cd or Zn) to receive the coating proper, (2) working with a very big current, and (3) rendering the metal passive. The last method is most commonly used. There are also special methods which will be dealt with under the individual cases.

The oxide film is dealt with by cleansing and pickling, the necessary processes frequently being more elaborate in the case of electrolytic deposition than in the case of other methods of coating. The metal surface is first degreased, then pickled, and then burnished with powdered porcelain or pumice, being thoroughly rinsed with cold water between each process. It is subsequently coated with a thin first layer of the most suitable metal.

A method has recently been introduced[14] whereby the surface of aluminium is prepared for electro-deposition by electrolytic deposit of an amalgam. A suitable bath is 10 grm. zinc chloride, 5 grm. mercuric nitrate, 200 grm. caustic soda, 200 grm. sodamide, 40 grm. stannous chloride, and 10 grm. KOH to 20 litres of water. The voltage required is 1·5; the time of the treatment a few minutes.

[14] E. d. Trairup. E.P. 339,339.

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Metal Plating.

In metal-plating aluminium the baths must (*a*) be well buffered; (*b*) contain a suitable addition agent (gum arabic, glucose, β-naphthol, peptone, gelatine, etc.); (*c*) have a definite pH value maintained. In general, sulphate baths are preferable to cyanide baths for aluminium.

Nickel, copper, cadmium, and zinc are plated directly on to aluminium, and combinations of Cd-Cr, Ni-Cr, Ni-Cu-Ni, or brass, silver, gold, lead, cobalt, etc., with an intermediate plating of one of the former metals, usually Ni or Cu. Nickel is plated on a roughened surface; copper, cadmium, and zinc on a smooth surface.

Nickel.—Nickel has proved perhaps the most satisfactory metal for coating aluminium. In the first place the coating adheres well, is dense, and takes a good polish; in the second place, it can be used as a preliminary for other platings which have not so far been directly producible.

In the standard methods[15] of plating nickel on aluminium, the aluminium, after ordinary cleansing, is made passive by pickling in caustic soda and treating with cold or warm concentrated nitric acid. (It is then sometimes washed with lukewarm water and dipped in 0·2% KCN solution until it has a silvery white matt surface.) It is then again washed and placed in an etching bath. There are a variety of formulæ for the etching solution:—

(1) Baths with high metal content—good for aluminium, less good for alloys.

(2) Baths with low metal content but high acid content—good for alloys but not for pure aluminium.

(3) Acid baths without metal—good for alloys with eutectic structure.

(The metals used are Fe, Mn, and Ni; the acid HCl.)

After etching the ultimate nickelling is carried out in baths of any of the following compositions:—

(1) $NiSO_4$ 120: $NaSO_4$ 195: NH_4Cl and boric acid, 15 g/l.

(2) $NiSO_4$ 140: $MgSO_4$ 75: NH_4Cl and boric acid, 15 g/l.

(3) Nickel ammonium sulphate 75: NaOCl 53: sod. citrate 7·5: boric acid 15 g/l.

(Baths (1) and (2) work with a current density of 1·5 A/dm^2, (3) with 0·8 A and pH = 6.)

In addition to the standard methods a number of special baths have been formulated.

A process[16] used in Germany is as follows:—The aluminium is first electrolysed in a bath containing 120 grm. sod. stannate, 120 grm. tin chloride, 120 grm. zinc chloride, 120 gr. copper acetate, and 30 grm. pot. hydroxide in 10 litres water (with anodes of lead), and is then nickelled in either of the baths (1) 4 kg. $NiSO_4$, 5 kg. $MgSO_4$, 300 grm. ammoniacal sod. citrate and 1 litre glycerine in 10 litres water, or (2) 5 kg. $NiSO_4$, 5 kg. $MgSO_4$, 35 grm. sod. carbonate, 20 grm. citric acid, 120 grm. glycerine in 10 litres water.

A method has recently been patented[17] which includes stoving as part of the process. The nickel, after smoothing and cleansing, is given potash (about 0·3%) and acid ($HNO_3 : H_2SO_4$: water, 11·5 : 57 : 31·5) dips, and is then plated in a sulphate bath of the composition $NiSO_4$, 3½ lb.: $NiCl_2$ 1 oz.: NaCl 3 oz.: water 1 gal. at a current

[15] Wogrinz—Langbeim—Pfannhauser.
[16] Werner.
[17] Smith and Velarde.

density of 15 A/sq. ft., and a temperature of 20-25° C., the pH value being about 5-6. The metal is then heated at 480° C. for 10-15 minutes. The contact surfaces of the aluminium and nickel are supposed to form an incipient solution at this temperature and alloy together, while the outer face of the plating is completely unaffected. It is claimed that by this method a much higher polish can be obtained on the plated surface, making a subsequent plating, with chromium, for example, capable of taking a high brilliance.

Nickel has been plated, using intermediate platings of zinc or copper, but the results are, in general, not very satisfactory. *Copper* is dealt with separately.

Zinc.—Zinc is more difficult to deposit on aluminium than nickel owing to its higher solution pressure, but zinc coatings afford better protection than nickel deposits under severe conditions.

The aluminium does not require to be pickled. It is instead, after cleansing, exposed to a sand blast and is well washed. The usual galvanising bath is a sulphate bath containing 145 g/l $ZnSO_4$ and 35 g/l sod. acetate plus 1 g/l gum arabic or other addition agent.

Cyanide baths containing 60 : 40 g/l or 60 : 30 g/l zinc cyanide/sodium cyanide and 30 or 20 ccs/l ammonia (0·880) can be used for preliminary plating for other metals.

Cadmium.—Cadmium plating is fairly easy, and cyanide baths give good results for this metal. The aluminium is rendered matt and passive in the usual way. A suitable bath is: Cadmium carbonate, 11 ; pot. cyanide, 35 ; sod. phosphate, 5 ; pot. ferrocyanide, 7·5 ; gelatine, 2·5 g/l. The current density is 0·5-0·7 A/dm² and the potential 3·5 V.

Metals Plated Indirectly.

Chromium.—Of the metals plated indirectly to aluminium chromium is of outstanding importance, and there is at present a big demand for chromed articles. Chromium can be satisfactorily plated over nickel or cadmium. The chroming bath is a sulphate solution, a typical one being: Chromium sulphate, 4 ; chromic acid, 250 ; sod. carbonate, 14 ; boric acid, 3 g/l. The bath is used hot (50° C.), and a current density of 13-17 A/dm² at 4-5 V is used.

(According to a recent patent, excellent results are obtained by chroming over a "stoved" nickel plate. See under *Nickel*.)

Lead.—Lead is plated from a perchlorate solution on to a "flash" copper plate over a primary zinc plate on the aluminium.

Other Metals.—Silver, gold, and numerous other metals can be plated over nickel. Brass can also be readily applied over the nickel, but due to the tendency for some cyanide baths to undermine the plating, particularly good nickel plating is needed.

VULCANISING.—It is now possible to fix soft rubber to aluminium by direct vulcanisation. The rubber has great resistance to corrosion and may be varied to suit the conditions, but it is, of course, injured by grease, especially mineral oils, and it will not stand a higher temperature than about 65° C., nor certain oxidising agents. A trade process, "Vulcalock," has been applied both to aluminium and duralumin.

COLOURING.—A good many processes exist for electro-treatment of aluminium to obtain a coloured surface. "Fescol" and "Alumilite" are trade processes which can be applied to give a range of colours or multi-tone effects. A good black surface is obtained by first nickelling and then electrolysing in an ammoniacal solution of ammonium molybdate (2 oz. amm. molybdate, ammonia (30%) 0·2 oz. per gal.) using steel anodes, and finally washing momentarily with HNO_3 or a HNO_3/H_2SO_4 mixture.[18]

[18] C. H. Proctor.

COPPERING.—Coppering has been given a separate heading as it has a special application for contact purposes. For this reason the plating has to be carried out with particular care to provide a non-porous homogeneous coating, which makes thorough contact with the base metal, and is sufficiently thick to be cleaned by filing or emery paper for bolted contacts. The best results are obtained for electrical work by subjecting the aluminium surface to a preliminary oxidation treatment ; after the anode treatment the metal is pickled in a hot (90–96° C.) bath of soda 25 grm. and sod. bicarbonate 45 grm. for 10-20 secs. It is then quickly rinsed and coppered in a bath with copper anodes (the current being already on). The electrolyte is a 10% solution of $CuSO_4$ and the current density should be 1 A/dm². The material is left for half to one hour, and to obtain sufficiently thick deposits is dried for one hour at 150–170° C., polished, and re-inserted in the plating bath[19].

For ordinary decorative purposes, or as a sub-plating for other metals, an acid sulphate bath—*e.g.*, $CuSO_4$ 100, HNO_3 60 g/l—is used, the current being 1–1·7 A/dm² at 1 V., and the electrolysis lasting 10–20 mins.

Cyanide baths cannot be successfully used even on increasing the concentration or by adding sodium phosphate, copper lactate, etc., as different workers have proposed.

The German trade name, "Cupal," covers a copper-plated aluminium.

BLACKENING.—Any of the methods of plating to give a black surface are suitable. The "Alumilite" trade process is used considerably.

MISCELLANEOUS.—There are a number of special electrolytic processes for producing surface coatings of various properties, the composition of the coatings frequently being very complex. One such process is the plating of aluminium in a bath of oxalic acid or oxalates. The coating obtained on the cathode is a combination of the oxalic root with the aluminium—a hard, yellowish-brown lustrous skin like adamantine spar. The metal thus coated is heat proof and electrically insulating[20].

International Foundry Exhibition and Congress.

MILAN has been chosen for the International Congress and Exhibition of 1931, and from September 12 to 27 all nations are invited to take part in this Italian congress. The machinery hall of the Milan Sample Fair has been utilised, and the exhibition promises to be very attractive as well as useful from a practical point of view to both exhibitors and visitors. The exhibition is divided into sections, and these cover such a wide field that considerable interest should be roused in it, while machinery in motion is to be a special feature. The foundry-equipment section includes all kinds of machines and appliances which go towards making the foundry a success, while the group devoted to castings should prove of more than usual interest.

As this is the first International Foundry Congress held in Italy, it is hoped that it will be well attended, and the Institute of British Foundrymen are organising a programme which, while giving those participating in it every opportunity for studying the various exhibits at the Congress, yet has been so arranged that the visit might well take the form of a holiday in Italy. Visits to the most up-to-date Italian works have been arranged, while receptions, a banquet, and excursions in the region of the Lombardy Lakes are being organised.

The Congress promises to be one of the most interesting that has yet been held, and Mr. T. Makinson, General Secretary of the Institute of British Foundrymen, St. John's Street Chambers, Deansgate, Manchester, will be pleased to give full particulars to all interested.

[19] H. Ginsberg.
[20] Kenkyuio.

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Business Notes and News

Serious Shipbuilding Decline.

A further decline in the amount of shipbuilding in progress in Great Britain and Ireland is indicated by the latest returns of Lloyd's Register of Shipping. The returns cover the three months ending June 30, 1931, and they show that not since the last quarter of 1887 has there been such a small amount of tonnage on the stocks. In Great Britain and Ireland only 555,603 tons are under construction, which shows a decrease of 138,211 tons from the work in hand last March, and is 836,460 tons less than the tonnage which was being built at the end of June, 1930.

The tonnage now under construction represents only 30·4% of the total amount of shipbuilding in progress. As the average percentage during the twelve months preceding the war was 57·2, the relatively high loss in percentage of the world shipbuilding is very disquietening. It is not surprising, under present conditions, that the National Shipbuilders' Security, Ltd., have been making further purchases of redundant and obsolete yards. The company has directed its attention to the North-East Coast, where eight shipyards are being purchased. These yards have a total of thirty-nine berths, and a maximum annual output of 276,000 tons. It will thus be appreciated that the deal is likely to have an important effect on the shipbuilding industry of the country.

Two of the yards concerned are situated at Stockton-on-Tees, and the balance are at Middlesbrough, Whitby, Sunderland, South Shields, Hebburn, and Howdon-on-Tyne. They are all confined to the building of cargo boats, the purchase being made in accordance with the policy of the directors, which is to secure a balanced reduction of facilities for the various types of shipyard work, with due regard to a proper apportionment of the reduction of capacity between the various shipbuilding yards. Altogether, the company has now purchased seventy-one building berths, with a total annual capacity of almost 500,000 tons, since it commenced operations a year ago.

International Chemical Plant Exhibitions.

Following the recent London exhibition of British chemical plant, in connection with the Society of Chemical Industry's Jubilee, a scheme has been provisionally agreed upon for co-operation between manufacturers of Great Britain, France, and Germany. The agreement is that future exhibitions of this nature in the three countries shall be organised and advertised in close collaboration, each country taking its turn for housing the exhibition. France will hold her next exhibition in 1932, Germany will follow with " Achema " in 1933, and the exhibition will again be held in Great Britain in 1934. The representative organisation in each country embracing the chemical plant industry will be responsible for organising parties to visit the exhibitions held in other countries. There is no doubt that American participation would be welcome in this scheme, but the distance creates a much bigger problem than with European countries.

A Works Management Association.

With the object of providing he means of personal contact between those engaged in works Management, a British Works Management Association has been founded, with offices at 68, Victoria Street, Westminster. The Association will provide opportunities for discussions on non-technical problems likely to be encountered in any works, and also for the interchange of managerial experience. Indirectly, it will have an influence in developing the technique of management, and thus tend to increase the efficiency of British industry. Membership of the Association is open to all who may be engaged in works and factory management, or in such branches of industrial administration, engineering, or research as may be determined by the Council. Members are to be persons of executive authority, while associate members may be accepted, who are otherwise qualified for membership but do not hold executive positions. Mr. E. J. Fox, the managing director of Stanton Ironworks Co., Ltd., is the first President of the Association, and the joint honorary secretaries are Mr. A. P. Young, B.Sc., and Mr. Clifton Reynolds.

International Aluminium Competition.

It will be remembered that, as announced in our December issue, the European producers of aluminium organised a competition in which prizes were offered for suggestions designed to develop the use of aluminium and its alloys. The Committee of judges has now finished the examination of the entries, and the following prizes have been awarded :—

1. A prize of 25,000 French francs, awarded to Mr. Constantin Szmukler, 1, Rue Chaper, Grenoble (Isere), France, for a contribution on the use of aluminium in leather dressing and tanning.
2. A second prize of 25,000 French francs has been divided equally between Dr. H. Hampel, Elsasserstrasse 15, Pojeduch, b. Stettin, Germany, and Mr. de Haes, 3, Rue de Veeweyde, Bruxelles-Midi, Belgium, for two entries relating to the use of aluminium in radiators for central heating systems.
3. The special prize of 50,000 francs has not been awarded, the judges being of the opinion that no suggestion made was of sufficient importance and exceptional novelty to justify this award.

The competition aroused great interest in technical circles in the majority of countries. Approximately 1,000 persons approached the International Aluminium Bureau for information on the competition, and eventually 291 entries were submitted to the judges. For the most part these entries were highly meritorious, and showed careful study of the properties of the light metals.

The Royal Aeronautical Society.

Wilbour Wright Memorial Lecture.

The Wilbur Wright Memorial Lecture will be delivered by Mr. Glenn L. Martin, on Wednesday, September 16, 1931, at 9-15 p.m., in the Science Museum, South Kensington. Mr. Martin will take as his subject " The Development of Aircraft Manufacturing." Following the lecture, the Society will hold a conversazione in the Aeronautical Section of the Science Museum. This date has been selected because at that time most of the foreign notabilities in the aeronautical world will be in England for the Schneider Trophy Contest, and will be specially invited to attend the conversazione, at which most of the leaders in British aviation will also be present. Applications for tickets for admission to the conversazione—5s. each—will be received from non-members. The programme for the Society's sixty-seventh session has now been provisionally arranged. Among many attractive items is included a lecture on October 8 by Professor Piccard, on his famous high-altitude balloon ascent.

Alloys of Iron Research.

In 1929 the Alloys of Iron Research was organised by The Engineering Foundation with the assistance of an advisory committee appointed by the American Institute of Mining and Metallurgical Engineers. With co-operation of the American Iron and Steel Institute, several technical societies, research institutes, and government bureaus, and a number of leading executives in the iron and steel industry, $230,000 was subscribed to finance the work for a period of five years. The Iron Alloys Committee was appointed to assume active charge.

The purpose of this research is primarily to review critically all research work on iron and its alloys, as reported in the technical literature of the world from 1890 to date, and to assemble the data thus collected in form convenient for reference; to publish information collected by this criticel review in two kinds of books : (*a*) monographs, for the scientist and research worker ; and (*b*) manuals, for the technician, the executive, and the engineer in the ferrous industries and related fields; and to call attention in these books to errors in existing data ; to define clearly the gaps now present in our knowledge of the alloys of iron, both of pure alloys and of commercial irons and steels ; and to encourage and promote research for basic facts to fill these gaps.

The organisation at the disposal of the Committee is very complete, and as the survey proceeds information will be collected on the alloys of 40 elements and compounds with iron, each in 20 classifications. In this way there is being rapidly built up a valuable body of reference material which may, and undoubtedly will, at some later time, be of great service to persons preparing research programmes, patent claims, and papers for technical societies.

Some Contracts.

The Weaver Navigation Trustees have awarded the contract for the construction of a 250-ft. span swing bridge to Messrs. Joseph Parks and Son, Northwich. The bridge is to be erected over the river Weaver at Acton Bridge, and we understand British steel is to be used.

Messrs. Ruston and Hornsby, Ltd., have, we understand, secured a repeat order from the Metropolitan Water Board for a vertical five-cylinder oil engine for the Honor Oak pumping station.

The Workso Town Council have placed contracts for electric cable with Messrs. W. T. Glover and Co.; 150 k.v.a. 3-phase transformer and remote control gear with the General Electric Co.

The Admiralty have placed orders for engineers' screwing tackle with Messrs. Pickford, Evans and Co., Messrs. G. and J. Hall, Messrs. Easterbrook, Allcard and Co., Messrs. J. Evans and Sons, and Messrs. Chas. Neil and Co.

The War Office has placed orders for steel with the Park Gate Iron and Steel Co., Rotherham, and the English Steel Corporation, Sheffield; for carbon tool steel with Messrs. Jonas and Colver, of Sheffield, and for bullet-proof steel plates with Messrs. Vickers-Armstrong, of Sheffield.

Ruston Bucyrus, Ltd., of Lincoln, have secured a contract from Russia for twenty-two Diesel, steam, and electrically driven excavators, the value of which is stated to be between £90,000 and £100,000.

The Admiralty have placed contracts with Messrs. Hadfield, Ltd., of Sheffield, Messrs. J. Beardshaw and Son, of Sheffield, and the Rotherham Forge and Rolling Mills Co., for steel sheets, discs, and squares; and with Messrs. Thomas Firth and John Brown, Ltd., Messrs. Samuel Osborn and Co., Messrs. Sanderson Bros. and Newbould, and Messrs. J. J. Saville and Co. for the supply of high-speed tool steel.

Orders for pumping sets for the London County Council have been received by Messrs. Worthington-Simpson, Ltd., of Newark-on-Trent, and Messrs. W. H. Allen, Sons and Co., Ltd., of Bedford.

Messrs. Swan, Hunter and Wigham Richardson have received two orders, one for a fast passenger steamer of 5,000 tons for foreign owners, and the other a 2,200-ton collier for Messrs. Stephenson Clark and Co., of London. The passenger vessel is to be built at the Walker-on-Tyne yard, while the collier is to be built at Sunderland. It is of interest to note that the latter order is the first one to be placed on the Wear for a considerable time.

Messrs. Wm. Gray and Co., Ltd., have received an order from Sir R. Ropner and Co., Ltd., for a steamer of 9,000 tons. The vessel is to be built at West Hartlepool, and will be the first to be laid down there for months.

The Wallasey Council have accepted the tender of Messrs. Harland and Wolff, Ltd., for a new ferry steamer for work on the Mersey. The new ferry will be built at Govan.

The General Steam Navigation Co., Ltd., have placed an order with Messrs. Cammell Laird and Co., Ltd., for a passenger vessel. She will be propelled by paddles, which are considered to be more suitable than screws for navigation in the Thames Estuary. The machinery will consist of triple-expansion engines with Scotch boilers burning oil fuel.

Messrs. Richard Dunston, Ltd., shipbuilders, of Thorne, Yorkshire, have received an order for a steam cargo vessel, dimensions 104 ft. 6 in. by 20 ft. by 8 ft., from Grimsby owners. It is intended for regular service between Grimsby and Hull.

The Sturtevant Engineering Co., Ltd., of Queen Victoria Street, London, have received an order for high-speed fans for three of the six ventilating stations of the Mersey vehicular tunnel.

Sir W. G. Armstrong, Whitworth and Co. (Shipbuilders), Ltd., have secured the contract for extensive repairs and reconditioning of the *Afric Star*, of the Blue Star Line, Ltd. This vessel has already arrived at the Walker-on-Tyne yard. The contract includes similar work on the *Stuart Star*, of the same line, which is due to arrive later.

Messrs. Crossley Motors, Ltd., Manchester, have received an order from Manchester Corporation Transport Department for 30 heavy-oil engined double-deck buses. This is the third repeat order for this type of Crossley vehicle received from Manchester Corporation.

Messrs. Dorman, Long and Co., Ltd., who are the main contractors for the steel works and rolling mills which the South African Steel and Iron Industrial Corporation, supported by the Union Government, are establishing at Pretoria, have instructed the English Electric Co. and the Asea Electric, Ltd., to proceed with the electric equipment. The former company will be responsible for the main electrical installations, while the latter has been entrusted with all the auxiliary motor equipments, including the motors, the starting and control apparatus, and also the cables and low-tension distribution plant. The value of this order is very substantial.

Welding Engineers' Competitions.

The Institution of Welding Engineers offer the Gold Medal of the Institution and a prize of ten guineas for the best original paper prepared by an operative welder, embracing either the oxy-acetylene or the electric processes. Arrangements will also be made for the winning paper to be read before a meeting of members of the Institution. In addition, other awards may be granted. The competition is open to operative welders, whether members of the Institution or not, resident in the British Empire.

The subject of the paper is "Welding and Cutting on Railways and Tramways," and the papers, which should be received at the office of the Institution not later than October 31, 1931, may cover work on rolling stock, locomotives, permanent ways, signals, bridges, etc. Intending competitors should apply for conditions and further particulars to the Secretary, The Institution of Welding Engineers, 30, Red Lion Square, London, W.C. 1.

New Standards Desirable for Rating Engineering Students.

Declaring that new "objective standards" by which college graduates may be measured will be necessary before the training provided by the technical schools of the country can meet the present requirements of industry, Mr. F. W. Willard, formerly director of personnel for the Western Electric Co., and head of their plant at Kearney, New Jersey, made suggestions as to what these standards must be in an address on "How Industry Rates the Prospective Chemical Engineer" before the Conference on Chemical Engineering Education, held at the University of Michigan recently.

"Intellectual accomplishment," he said, "is at the present time the only objective standard by which the graduate may be measured—and it is not in itself enough. There should be similar standards by which aptitude and personality can be measured."

Mr. Willard expressed the belief that if such standards could be found and employed at the technical schools of the country, they would "have fewer men to teach and fewer to graduate, but they would find that all of their graduates could be placed in industrial firms simply upon the recommendation of the college authorities. Responsibility for the present unsatisfactory handling of the college graduate is not all the fault of the schools, Mr. Willard said, but is in part that of industry. By its very nature, he pointed out, industry has been forced to be ruthless in its treatment of new material and this ruthlessness has sometimes been unintelligent

"Our political organisation," he said, "is still agrarian, but our economic organisation is industrial. The educational standards in such professions as law and medicine cannot apply perfectly in engineering, because law and medicine are professions based upon personal service." Part of the responsibility which must be charged to the colleges, in his opinion, is that it has been too easy for the student to enter such an institution.

Some Recent Inventions.

A STEEL FOR SUPERHEATER AND BOILER TUBES.

DEVELOPMENTS in modern steam plant have necessitated much time and thought in devising and producing materials capable of withstanding increased difficulties of service. It is now recognised that the satisfactory and economic design of plant subjected to high steam pressures and increased temperatures of superheat involves the employment of materials of special composition and quality. A superior steel of this character has recently been developed which is claimed to possess high powers of resisting scaling and oxidation by furnace gases, and scaling and attack by high-pressure steam, and which is particularly suitable for the manufacture and working of superheater and boiler tubes. Its composition consists primarily of chromium, silicon, carbon, and manganese, although small percentages of nickel, cobalt, molybdenum, tungsten, vanadium, or titanium may be added without destroying its essential properties. The percentage of these components have the following limits :—

Cr.	Si.	C.	Mn.
4·0 to 10·0%	0·2 to 0·7%	0·05 to 0·20%	0·2 to 0·45%

As manufactured, this steel has a satisfactory strength at the temperatures usually employed in steam-boiler work, and possesses at such temperatures a reasonable creep strength. Experiments on a steel manufacture as a result of this development, and having the following composition :—

C.	Si.	Cr.	Mn.	S.	P.
0·105%	0·36%	7·36%	0·33%	0·018%	0·015%

gave the following physical properties after being annealed at 780° C. for one hour :—

Yield point	15·2 tons per sq. in.
Maximum stress	31·8 ,, ,,
Elongation on 8 in.	30%
Contraction	76·4%
Bend test	180° without fracture
Izod impact	98 ft.-lb.

The material does not harden up to a temperature of at least 760° C., so that local overheating, which is always possible, does not lead to any dangerous condition or any liability to fracture in tubes manufactured from it. This is indicated by the results of tests on samples of this steel which have been heated up to the following temperatures and then allowed to cool freely in air :—

Temperature in °C.	15	100	200	300	400	500	600	700	760
Brinell hardness	121	121	117	121	121	125	121	121	121

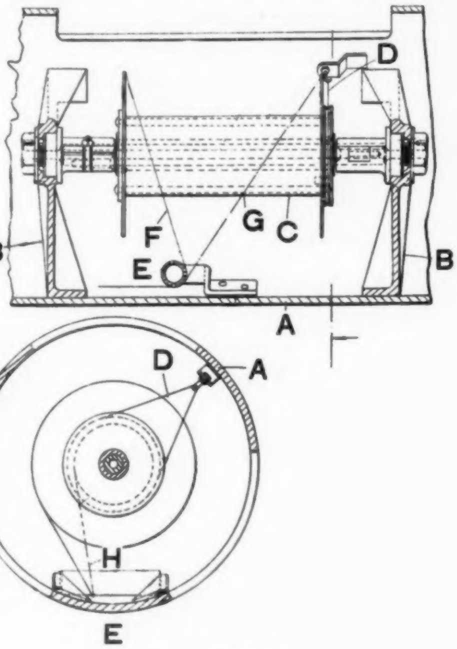
The ability to resist oxidation at high temperatures in air or furnace gases is much superior to mild steel.

350,048. DAVID COLVILLE AND SONS, LTD., and ANDREW McCANCE, D.Sc., of Glasgow, patentees. H. D. Fitzpatrick and Co., agents, 94, Hope Street, Glasgow. Accepted June 11, 1931.

IMRROVEMENTS IN WIRE-STRANDING MACHINES.

WHEN wires are twisted together as a whole, the combination is usually referred to as a strand, and the operation of twisting the wire is known as stranding, the principle of which is similar to that which forms strands into a rope. By similar machines wire is twisted round electrical cables to give mechanical strength. These machines may embody different methods of stranding, but each wire used in the operation of stranding is wound on a drum or bobbin, which is carried on a pin or spindle. The bobbins are carried on fliers, which rotate and twist the wires while the strand is pulled through a die by the rotation of a drum on which the completed strand is given sufficient turns for driving purposes.

In some types of machines the bobbins are placed one behind the other along the axis of rotation ; this arrangement is usually adopted for the purpose of permitting a high speed of revolution. These machines are frequently required to strand wires round a central wire or stranded core coming from a bobbin or another machine placed behind the stranding machine. In such a method of operation the central wire or core must pass through the first machine from end to end, and with the object of permitting this passage of the wire without bending or twisting



Figs. 1 and 2.

it, or disturbing the lay of the wire in the strand, a new method has been developed.

The supply bobbins are placed one behind the other in the frame of the machine, and along the axis of rotation. The bobbins are arranged with their axes in line, and each bobbin is mounted on a separate tubular spindle, supported by suitable parts secured to the frame. These parts are formed so that a central wire or strand can pass through all the spindles in a straight line from end to end of the machine.

A sectional side elevation of a machine of the tubular type is shown in Fig. 1, while a sectional end elevation, with the front bracket removed, is shown in Fig. 2. The tubular frame of the machine is shown at A ; this carries a number of three-armed brackets B, each pair of which support a bobbin C. The bobbins are mounted on a hollow spindle in such a way that they are allowed to rotate freely while wire is being drawn off. The rotation of each bobbin may be controlled in the usual way by rope brake, as at D. To guide the wire in its passage from each bobbin to the front of the machine, freely rotating rollers are mounted at E, near to the wall of the frame. The positions of the wire when leaving a full bobbin, and at the left and right are shown at F and G, and as the bobbin becomes unwound the wire assumes a position as shown at H.

When the spindles and their bobbins have been placed in position parts are clamped together to prevent the spindles rotating, leaving the bobbins free to rotate as wire is drawn from them, and in order to permit a wire or strand to pass through each spindle, all the fitments about the spindle are provided with apertures which are brought into alignment, when the parts are assembled, so that the hole is continuous the full length of the machine.

349,202. W. T. HENLEY'S TELEGRAPH WORKS CO., LTD., Holborn Viaduct, London, E.C. 1, and G. S. HARBIRD Rosherville, Kent, patentees. R. L. Cleaver, agent, Cable Research House, Silver Street, London, W.C. 1. Accepted May 28, 1931.

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2-4% Carbon, scale 11/- per unit	ton	28 0 0
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§ Ferro-Vanadium 25-50%	,,	0 12 8
§ Spiegel, 18-20%	ton	6 17 6
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	5 17 6
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,, No. 3	2 18 6
,, No. 4	2 17 6
Cleveland—	
Foundry No. 3	2 18 6
,, No. 4	2 17 6
Silicon Iron	3 1 0
Forge No. 4	2 17 0
N.W. Coast—	
Hematite	4 4 6
Midlands—	
N. Staffs Forge No. 4	3 1 0
,, Foundry No. 3	3 6 0
Northants—	
Forge No. 4	2 17 6
Foundry No. 3	3 2 6
Derbyshire Forge	3 1 0
,, Foundry No. 3	3 6 0
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Midlands	8 17 6
Boiler Plates (Land), Scotland	10 10 0
,, ,, (Marine) ,,	10 10 0
,, ,, (Land), N.E. Coast	10 0 0
,, ,, (Marine) ,,	10 10 0
Angles, Scotland	8 7 6
,, North-East Coast	8 7 6
,, Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 0 0
Light Rails ......£8 10 0 to	8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic .. £8 2 6 and	8 12 6
Medium Basic.. £6 12 6 and	7 2 6
Soft Basic	6 0 0
Hoops..........£9 10 0 to	9 15 0
Manchester—	
Hoops..........£9 0 0 to	10 0 0
Scotland, Sheets 20 W.G.	9 10 0

HIGH SPEED TOOL STEEL.

Finished Bars 18% Tungsten.	lb.	2/9
Extras		—
Round and Squares, ½ in. to ¼ in.	,,	3d.
Under ¼ in. to 3/16 in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅜ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£109 0 0
English	111 10 0
Australian	111 17 6
Eastern	114 15 0
Tin Plates I.C. 20 × 14 box	13/6 to 13/9
Block Tin Cash	£114 2 6

ZINC.

English Sheets	£20 10 0
Rods	22 0 0
Battery Plates	15 15 0

* McKechnie Brothers, Ltd., quoted Aug 8. † C. Clifford & Son, Ltd., quoted Aug. 10. ‡Murex Limited, quoted Aug. 10.

Subject to Market fluctuations, Buyers are advised to send inquiries for current prices.

Lancashire Steel Corporation's Current Basis Prices, f.o.b. Liverpool or Stations in Lancashire :—Wrought Iron Bars, £9 15s. 0d. ; Mild Steel Bars, £6 10s. 0d. ; Wrought Iron Hoops, £11 10s. ; Best Special Steel Baling Hoops, £8 5s. 0d. ; Soft Steel Hoops (Coopers' and Ordinary Qualities), £7 15s. 0d. ; C. R. & C. A. Steel Hoops, £11 10s. 0d. "Iris" Bars, £8 5s. 0d. All Nett Cash. Quoted Aug. 10. § Prices quoted Aug. 10, ex warehouse.

Shipping, Engineering, and Machinery Exhibition

Olympia, September 10-26, 1931

A review of exhibits on which an endeavour is made to emphasise new and salient features. Space limitations prevent the article being completed in this issue, and there will be further descriptions in the September issue of "Metallurgia" before the publication of which the Exhibition at Olympia will be open.

SIR W. G. ARMSTRONG WHITWORTH & CO. (ENGINEERS), LTD., SCOTSWOOD WORKS, NEWCASTLE-ON-TYNE.

Fig. 1 shows a 3½-cwt. Armstrong Whitworth Semi-Rotary Open Flame Metal Melting Furnace. The furnace is lined with a high-grade refractory material capable of withstanding many hundreds of heats. Other features of note are:—

(*a*) The metal melted is free from gas contamination.
(*b*) The metal losses are extremely low.
(*c*) The furnace may be started up with a full charge.
(*d*) The exceptionally short time required between melting to pouring temperatures.

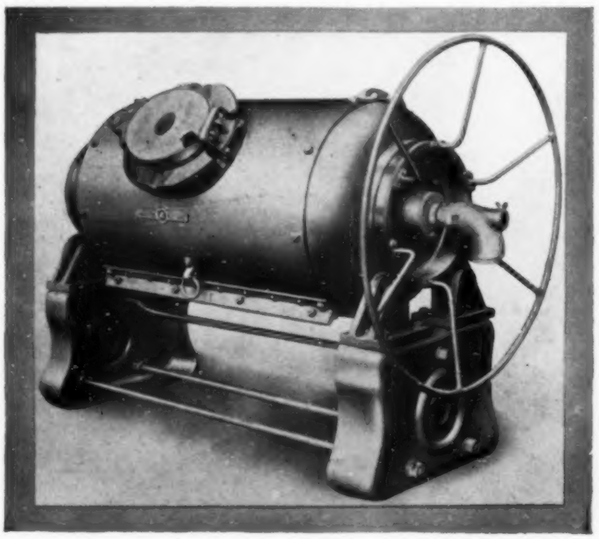

Fig. 1.

In addition to the size exhibited, this furnace is also made in a larger size of 1,000 lb. (brass) capacity. It may be fired by either gas or oil to suit any particular requirements.

Armstrong Whitworth will show also their printers' type-metal furnace of ½-ton capacity, and plant for the die-casting of connecting rods, and also die-casting machines for white-metalling large marine-type bearings, etc. This interesting exhibit includes a full range of A-W pneumatic tools, including chipping and riveting hammers, pneumatic drills, grinders, concrete breakers, etc.

A feature of this firm's exhibit will be specimen fractures of their new-process pig iron and complete castings of this remarkably pure iron; while heavier exhibits will be the new Armstrong-Whitworth Sulzer-type Diesel engine of 250 h.p. and a No. 14 high-duty "Spencer-Hopwood" boiler equipped for oil firing.

THE UNITED MACHINE TOOL CO., LTD., LONDON.

The "Union" Horizontal Boring, Milling, and Drilling Machine, Model LOc., Fig. 2, which will be shown by the above firm is arranged for direct motor drive by standard motor. Diameter of spindle, 3 in.; boring capacity, up to 13 in.; maximum distance table to spindle, 30 in.; maximum distance spindle nose to bearing in boring stay, 80 in.; table, 32 × 40 in.; net weight, 10,200 lb.

The characteristic features of the machine are the large range of 12 spindle speeds, from 11 to 268 r.p.m., and the extra wide range of 24 feeds from 0.001—0.787; further, the self-alignment between spindle and bearing in boring stay; quick power traverse always acting in the opposite direction to the adjusted feed and without interfering with same, by operating a single lever; indexing main table of machine with four quartering positions. Most important of all is the high degree of accuracy of "Union" horizontal boring machines and the handiness and close grouping of all controls.

The "Pittler" Maxi-Speed Automatic Turret Screw Machine, Model Astron-18, Fig. 3, will be exhibited by the United Machine Tool Co., Ltd. The characteristic features of the machine are that the turning and screwing speeds are by a patented arrangement entirely independent from one another, so that any combination within the exceptionally wide ranges of speeds can be used. The utility of these machines is consequently universal, as such different materials as ebonite, aluminium, and mild steel can be handled with equal efficiency. Three modes of indexing the turret are available: (1) Continuous indexing from tool-hole to tool-hole; (2) intermittent indexing by passing over every second tool-hole; and (3) pendulum indexing when only two tool positions in the turret are occupied.

Bar capacity, ¾ in.; feeding length, 3 in.; turning length, 2 in.; number of turning speeds, 10 (ranging from 350–4,380); number of screwing speeds, 10 (ranging from 208–2,000); net weight, 2,650 lb.

The machine will be shown in operation producing two

Fig. 2.

different telephone components in 10 secs. In addition, there are on view a complete range of "Pittler" Self-opening Die Heads and Collapsible Taps.

The genuine "Pittler" Turret Lathe, Model Fra, as shown in Fig. 4, with all-geared head and drive by standard motor, will be on view. Capacity for bar work, up to 2 9/32 in.; greatest turning length, 26 3/8 in.; capacity for chuck work, 11 13/16 in.; eight feeds; 16 spindle speeds from 20 to 600 r.p.m.; net weight, 7,190 lb.

The vertical turret head accommodates up to 16 tools, is of extra rigid construction on account of the horizontal arrangement of the turret-head spindle giving ample room for providing a strong and long turret-head spindle. The tooling is extremely simple, by single point tools even for the production of form parts. The absence of a crosss-lide is characteristic, because the rotary power feed of the turret head around its horizontal axis not only substitutes the action of an independent cross-slide, but increases the accuracy of the work produced on account of both longitudinal and transverse (rotary) feed movements being carried out by the turret head itself. The machine will be shown in operation producing a complicated steel bolt 10 in. long from the bar.

The "Braun" Column Radial Drilling Machine, shown in Fig. 5, is characterised by the mounting of the column directly upon the work-table instead of the usual baseplate mounting for machines of this size. Designed as a "manufacturing" unit for the motor and kindred trades, this machine has a working radius up to 3 ft., and a spindle-above-table clearance of 2 ft. 3 1/2 in.; a saddle-mounted motor gearbox unit drives the spindle through 24 spindle speeds of range 80–1,200 r.p.m., this drive being practically "straight line"; there are six feeds, ranging from about 5 to 50 thousandths.

We understand that this type of Braun radial is standardised in one size only, and such standardisation obviously has produced a drilling unit of "sensibly" rugged proportions. The arm is of oval section with zigzag webbing. It is claimed that this construction so resists bending and torsion as to permit a maker's guarantee of maximum horizontal deflection of 0.018 in. per foot with 2-in. drill operating at extreme radius under heaviest feed.

The gearbox has motor-car-type sliding gears of 85 tons tensile nickel-chrome steel on 6-spline shafts. The tapping unit is so designed that all spindle speeds may be reversed instantaneously without any halt in "neutral." A penetration of 4 in. through cast iron in 85 secs., and through steel in 265 secs., with a 2-in. drill, is proved by maker's test. The net weight of the machine is 3,860 lb.

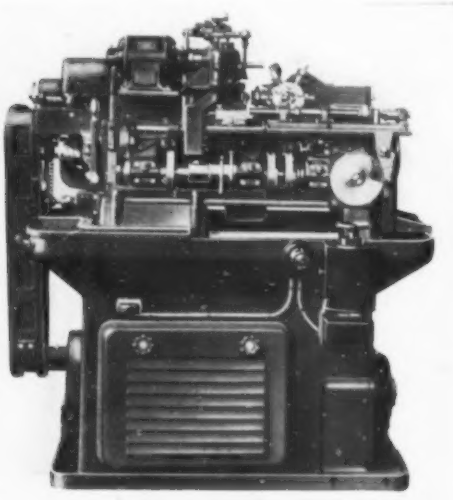

Fig. 3.

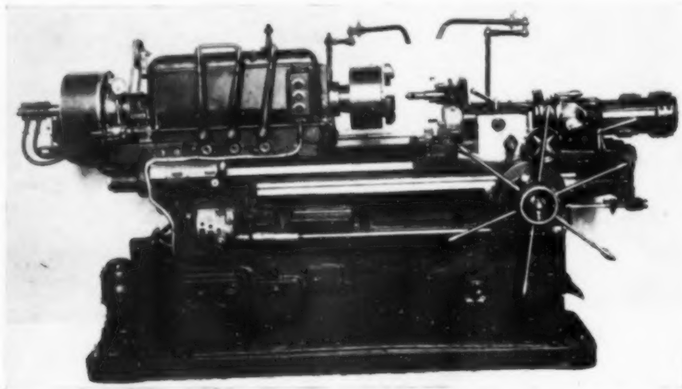

Fig. 4.

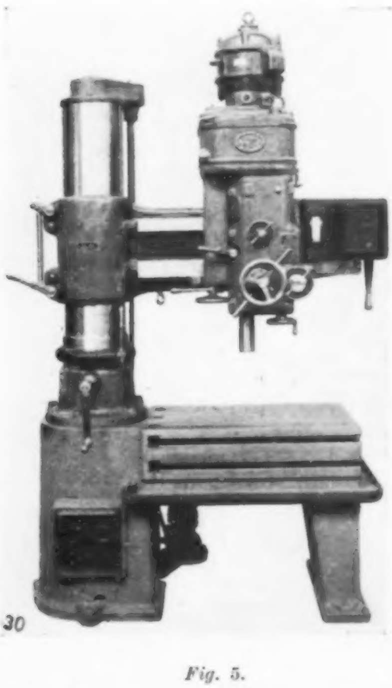

Fig. 5.

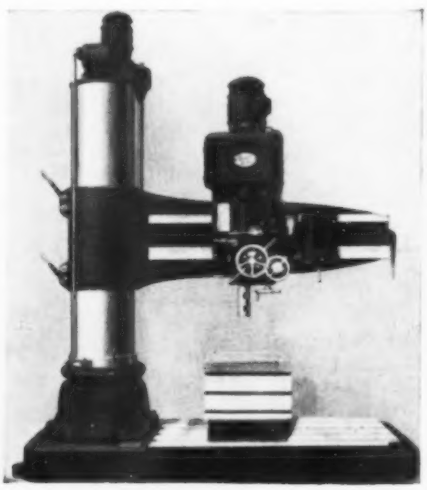

Fig. 6.

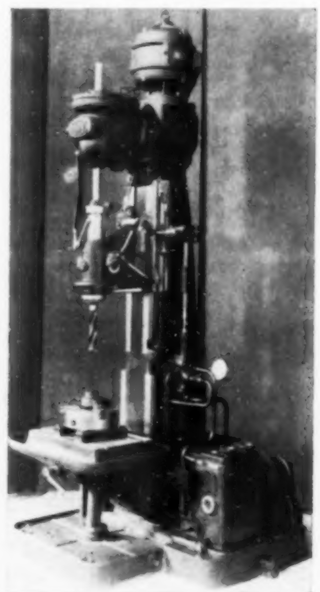

Fig. 7.

Fig. 6 shows a Heavy-duty Column Radial Drilling Machine by Braun. This type is made in four sizes, these being 3 ft. 7 in., 4 ft. 7 in., 5 ft. 7 in., and 7 ft. 5 in. drilling radii, the machine illustrated being the 4 ft. 7 in. size. Arm construction is similar to that of the T.R.B. 30, already described, as is the method of motor gearbox "straight-line" spindle driving.

This model has ground cylindrical outer column, surrounded by the sleeve of the arm. The inner column tapers upwards and has strong star-shaped ribs. Suspension of outer upon inner column is by separate thrust and radial ball bearings at the top with radial roller bearings at bottom, giving "finger-light" arm swing.

The makers have legislated for H.S. steel and for the new higher speed cutting alloys by providing a choice of three alternative spindle-speed ranges, arranged in geometrical progression with a step-to-step ratio of 1 : 1.26. It is also interesting to note that with the use of a D.C. variable-speed motor a finer grading of the spindle speeds is possible (up to 64 different speeds, for example). Briefly, the range of available spindle speeds is from 32–1,200 to 51–19,000. There are 12 feeds of range 0.0047 in. to 0.0501 in. Tapping, trepanning, and blind-hole drilling are provided for by sensitive reversing gear. Current consumption is shown by ammeter. The net weight of this model is 10,400 lb.

The United Machine Tool Co., Ltd., will also have on their stand the "Hille" Heavy-duty Column Drilling Machine, Model St. Ioe. This machine (Fig. 7) is a representative of a new range of heavy-duty column drilling machines, the outstanding feature of which is a new type of hydraulic feed gear. The characteristic feature of this hydraulic feed gear is the absence of a reducing valve. The gear employs a stationary pump cylinder with a variable stroke of the supply piston. The oil is automatically freed from all air, ensuring a low oil temperature even at a pressure of 1,000 lb. per square inch. The volume of oil used is practically constant for all pressures between minimum and maximum, and it is, therefore, possible to adjust the required feed according to a graduated scale by one handwheel, irrespective of the size of the drill used and the resulting drilling pressure. The hydraulic gear is governed by adjustable dogs which control the quick advance of the spindle in power traverse, the automatic changing over to the working feed, and, on completion of the cut, the automatic quick return traverse to the starting position, when the machine either stops (semi-automatic) or re-commences the cycle (full automatic). The machine can be had with an automatic self-indexing table for full automatic working.

LEO. C. STEINLE, LTD., LONDON.

The rapidly developing industry of plastic-material moulding is served by the press shown in Fig. 8, which is one of a range supplied by Leo. C. Steinle, Ltd. The model illustrated will be shown at Olympia for the first time in this country.

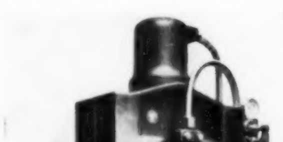

Fig. 8.

Fig. 9.

These high-speed hydraulic presses are operated by a new pump, the advantages gained by using which are :—

Expensive accumulator systems and long pipe lines are eliminated ; quick approach and return of ram by means of the low-pressure stage of the pump, with large oil supply; automatic change from low to high pressure by an automatic valve in four to five seconds; quick pressure control by a handwheel giving any desired pressure from 300 to 5,000 lb. per sq. in. ; high efficiency at very low power and maintenance cost.

The operating lever of the press has three positions—neutral, pressure or downward movement of ram, upward movement of ram. When starting the machine by pushing

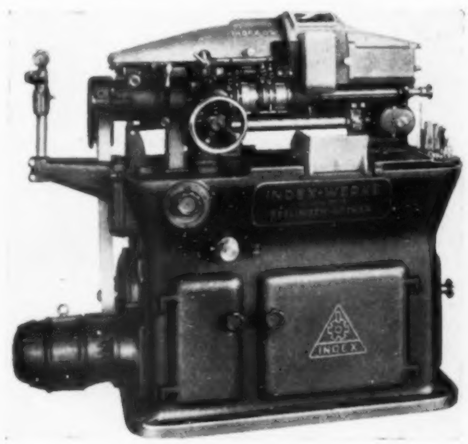

Fig. 10.

the operating lever forward, the low-pressure stage of the pump, with a large oil supply, brings the ram quickly to the work. As soon as the ram comes to the work, a hydraulic change-valve brings a high-pressure stage of the pump into action. The change from low to high pressure is gradually effected within four or five seconds. Steinle furnishes moulds with the presses, and typical moulds and products are on show. If desired, the presses come equipped with electrical heating and heat-control gear.

Fig. 9 shows the new "Heller" Vertical Cold Circular Saw, also to be exhibited by Messrs. Steinle. The main characteristic is the ability to cut sections at any angle, a divided circle giving bold and accurate angular readings.

The drive is effected by a flange motor mounted on the saw carriage.

The saw head swivels through 360°—*i.e.*, a complete circle runs on a step-gearing, and can be easily adjusted to any cutting position. Hand motion is provided for this adjustment on all sizes of these machines. In the machines type VZ 650 and VZ 800, the saw head has also a power swivel motion. Fine adjustment of the saw head is effected by means of a double-taper lock collar.

Fig. 11.

The feed gear is carried in the apron fitted on the side of the saw carriage. The machines, type VZ 300, VZ 400 and VZ 500, have two, the other sizes four feeds. The amount of feed can be varied within wide limits by means of change-wheels.

E

The feed motion is brought by a worm-gear engaging a pinion and rack. An enclosed safety clutch either reduces or disengages the feed motion in the event of overloading of the saw blade. Lubrication of the feed-gear is effected by a rotary oil-pump.

The saw carriage has quick power return, which comes into action automatically when the prescribed depth of cut has been attained. Adjustable end and depth stops are provided. The saw carriage has also quick hand traverse in both directions by means of a handwheel. The table forms a self-centring vice, the work always being held under the middle of the saw blade. It is to be noted that the maker supplies a hydraulically-operated vice, if required.

An interesting new automatic lathe is shown in Fig. 10. This is the " Index O.R.", described by the maker as a " high-production automatic turret screw machine." This model is entirely new, and will be shown for the first time in this country. The aim of the designers was to combine the wide work range of their well-known " Index " turret screw machines with the high (automatic) productivity of their " Index O " model.

The machine is equipped with four swinging side tools with a 6-port turret. Drive is by countershaft in the cabinet base, a feature which makes the machine neatly compact. Power is by flanged motor or single pulley ; from this countershaft both main spindle and threading attachment are driven. Eight main spindle speeds are available. Spindle direction is constant, threading being accomplished by differential " overtaking."

The stock " quick-feed " may be quickly and accurately adjusted to length, one-third turn of the cam-drum operating this simultaneously with the quick-chucking operation. In this connection it is interesting to note that, by means of three quick-operating clutches, the feeding and chucking of the stock bar, the indexing of the turret, and the engaging of the threading device are all effected in one-third of a second.

The side tools, usually consisting of forming-tool, cutting-off tool, and stock-stop, are operated from the upper main camshaft. (In addition, a longitudinal turning attachment is avilable, capable of radial and longitudinal movements.)

The threading spindle is arranged in two opposed turret ports, the other four being available for tool holders.

All movements are automatically stopped when bar is used up, so that insurance is provided against idle running or tool damage.

The chucking capacity of this model is $\frac{1}{2}$ in. diameter round, $\frac{11}{32}$ in. square (across flats), and $\frac{7}{16}$ in. hexagon. Maximum feed of bar-feeding mechanism, $1\frac{9}{16}$ in. Threads are cut up to $\frac{1}{4}$ in. diameter for steel, and $\frac{5}{16}$ in. diameter for brass. Minimum threading diameter is $\frac{5}{64}$ in. The machine will be found at Olympia, set up, and " in production."

The " Beche " Hammer, shown in Fig. 11, is a powerful forging unit. Separate air-compressing and hammer cylinders are provided, an ingenious system of rotary valves controlling the force of blow. For maximum force, the air compressed in the compression cylinder can be delivered directly to the top side of the tup plunger. Means are provided for the return stroke to be accelerated by vacuum behind the compressor piston assisted by back pressure behind the tup plunger.

The tup consists of one homogeneous piece of special steel, the upper end being formed by hot crimping. The perfectly closed and hollow tup results in a high section modulus being available over its entire length, by the carefully calculated tapering upwards of the walls, giving maximum strength in the vicinity of the die seat. This design is claimed to have an advantage in strength, weight for weight, with a rod-type tup of twelve to one.

The " Beche " hammer is offered in a variety of sizes ranging from total weights of less than 5,000 lb. to 150,000 lb., and of tup weights of 66 lb. to 4,400 lb. Drive is by motor or belt, as desired. Hammers having tup weights of 66 lb. to 385 lb. are equipped with hand and foot control. Anvil positions are adjustable on the base.

The control is sensitive and simple. Valves are provided with idle running arrangement to facilitate starting. The tup has a double buffer to guard against striking the cylinder cover, through carelessness.

A device is provided for imparting separate stretching or squeezing blows. The tup bears down on all blows under pressure, giving maximum work deformation per blow. All " Beche " hammers are equipped with Bosch central lubrication.

S. WOLF & CO., LTD., LONDON.

The " Boley " Multiple-Spindle Drilling Machine and Tapping Machine (Fig. 12) is designed for both drilling and tapping. It is available in two types—one with 10 spindles and one with 13 spindles. The spindles are readily detachable and can be removed very quickly ; it is not necessary to use the maximum number of spindles for which the machine is designed, but any number from one upwards can be fitted.

In the case of the 10-spindle machine, spindles for two different speeds can be fitted, the maximum speeds being 3,000 r.p.m. and 2,200 r.p.m. The 13-spindle machine takes spindles for one speed only—namely, 3,000 r.p.m. The spindles are secured into the working position by means of a bracket which is bolted to the spindle carrier frame. This frame can be supplied either in a normal circular size to cover a diameter of $5\frac{3}{4}$ in., or with a rectangular frame which will

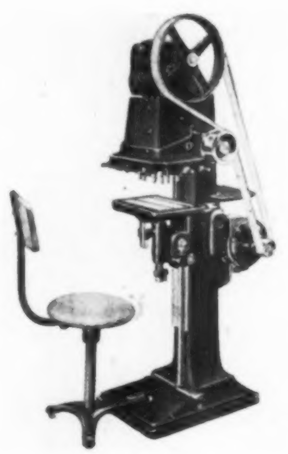

Fig. 12.

Fig. 13.

cover 10 in. × $5\frac{1}{8}$ in. A special circular frame can also be supplied, and this will cover from $2\frac{3}{8}$ in. up to 8 in. diameter.

The " Boley " Tapping Machine (Fig. 13) is of a very similar design to the drilling machine, with the exception that it has an automatic reverse to the spindles, so that when the tapping is completed the reverse comes into operation, and the spindles rotate in a left-hand direction. In some cases, where the holes in a part have to be tapped with varying sizes or pitches of thread, the tapping can be carried out in one operation by fitting sliding collets for the smaller-sized holes.

For this class of work the 10-spindle machine is a decided advantage, as this allows the small diameter taps to be carried in high-speed spindles whilst the larger taps can be adjusted to rotate at the lower speed. In addition to drilled plates

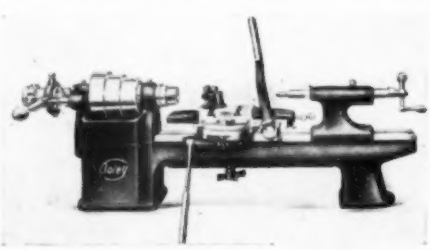

Fig. 14.

and similar parts, the " Boley " Multiple Spindle Machines are designed for the drilling of small switch parts and components of wireless and telephone apparatus. In such cases special jigs are used. High outputs characterise the use of the machine for the work for which it is designed.

The range of " Boley " Precision Lathes covers small instrument makers' lathes with centres of 50 mm. and 65 mm., and a heavier range with centres of 90 mm. ($3\frac{1}{2}$ in.) and 120 mm. ($4\frac{3}{4}$ in.). Two screw-cutting models are included. The screw-cutting lathes can be supplied with English lead

screw to special order. All lathes are constructed with draw-in coilet and hollow spindle. A full range of collets in millimetres and fractional inch sizes are kept in stock in London.

Attention is drawn to the lathe illustrated by Fig. 14. The bed of the lathe is slotted to allow the driving-belt to pass below, and through the bench on which the lathe is mounted. Special driving motors can also be supplied for

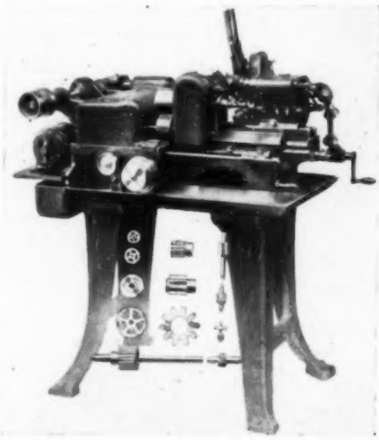

Fig. 15.

these lathes. The new range of "Boley" lathes includes machines for independent electric drive. Complete sets of attachments which transform this beautifully fine precision tool into a miniature machine shop are on view at Olympia.

The Koepfer Gear and Pinion Hobbing Machine, which will be shown by Messrs. Wolf, is made in two sizes. The machine, as typified in Fig. 15, is designed for generating spur-wheels, pinions with straight teeth, and worm-wheels. The main drive is direct from main line without countershaft. The cutter is positively gear driven, the side thrust which attends the belt-driving of cutters thus being eliminated. Feed and return feed are accomplished positively by eccentric, no springs being used. Setting of the length is by simple set-screws. The feed can be stopped in any position. The change of the cutter speed is accomplished by the use of change-wheels.

Type "WM1" is the second model and gives larger output, this machine being equipped with a magazine and automatic chucking and releasing device. We are informed that this fully automatic machine is the only one of its kind with magazine feed. The addition of this feature produces an output of 25% to 30% greater than the semi-automatic type, because all loading-stopping time losses are cut out. Typical productions are 60 steel pinions, 16 teeth, 32 D.P., 10 mm. length of tooth per hour; 400 brass pinions, 12 teeth, 42 D.P., 12 mm. length of tooth per hour; and 150 brass worm-wheels, 24 teeth, 33 D.P. per hour.

WILD-BARFIELD ELECTRIC FURNACES, LTD., LONDON.

The new design of Carburising and General Heat-Treatment Furnace consists of heavy nickel chrome hairpin rods running the complete length of the furnace in roof, walls, and floor, and, when necessary, in the door and back. The elements can be removed and replaced with ease and simplicity; even when the furnace is at working temperature the old element can be withdrawn by unscrewing two nuts at the back and pulling the hairpin out of the chamber with a pair of tongs; a new hairpin being placed in position with equal ease. For furnaces over 8 ft. to 9 ft. long the hairpin-rod construction gives way to Hevi-Duty construction which consists of drawn-rod elements of sinuous form. The furnace is shown at Fig. 16.

The drawing (Fig. 18) shows the general arrangement of the "W.-B." Pit type Forced Draught Oven. Natural convection is augmented by the Wild-Barfield Patent Paddle Fan situated under the chamber, this type of fan having a very high efficacy. It follows that the rate of heating and the resulting output of heat-treated work is greater for a given size oven or furnace when this fan is fitted. The arrows in the illustration show the direction of the air stream, which passes over the heating elements and both round and through the charge.

The actual rate of heating of the charge and the moment when it reaches the required temperature are recorded by an ingenious arrangement of thermocouples, thus relieving the operator of the responsibility of determining when the charge is ready for withdrawal. It will be apparent that modification of this type of oven lends itself to other forms of heat-treatment, for example, furnaces for the heat-treatment of non-ferrous metals, both in sheet and finished form. A variety of sizes and shapes are made to suit different manufacturers' requirements.

A working model, with an outer cylinder of glass containing a motor-driven paddle fan, will be operating on the stand, and by a simple arrangement of minute particles the air circulation through and around the container holding the charge will be demonstrated.

Another development to be exhibited is a Pusher-type Furnace, especially designed for quantity production of parts such as gudgeon pins and similar articles, no energy being wasted by heating conveyers or similar parts. The work is pushed through by reciprocating arms driven through suitable reduction gear by a motor mounted on the main framework. The apparatus is therefore compact, utilising little floor space.

Wild-Barfield will also show the Vickers Diamond Hardness Testing Machine, for which they are distributors, together with the Vickers Works Projection Microscope.

The exhibit from G.W.B. Electric Furnaces, Ltd., will comprise a show case of "Eternite" Carburising Compound of various sizes, and various types and grades of firebricks will be displayed, together with a selection of photographs of large mechanically operated and similar furnaces, manufactured under Hevi-Duty patents. This company has the sole rights to manufacture and sell these equipments in Europe and the British Empire, only the size of them preventing an actual example being exhibited.

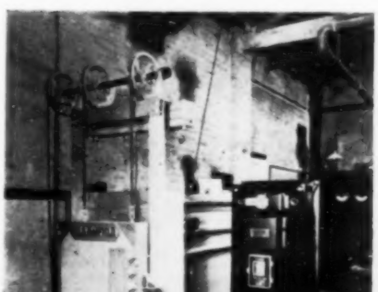

Fig. 16.

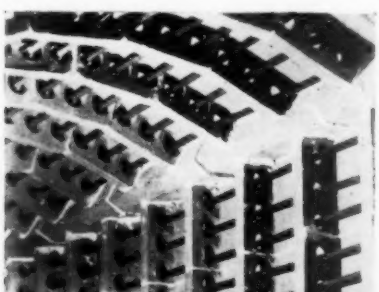

Fig. 17.

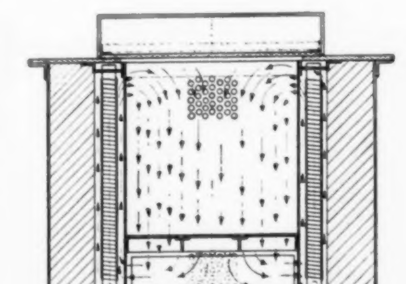

Fig. 18.

SELSON ENGINEERING CO., LTD., LONDON.

All the well-known advantages in Cleveland design have been retained in the New Model M, Multiple Spindle Bar Machine, Fig. 19, permitting use of standard tools, avoiding the necessity of costly tooling combinations. The ribbing and distribution of metal is arranged to give maximum strength, and as the spindle and tool turret housings are cast integral with the main bed casting, positive alignment between the turret tools and work is assured.

Power from the driving pulley or chain sprocket is transmitted through a friction clutch. The throwing in or out of the friction clutch stops and starts the machine, and is a decided convenience in setting up. The spindles and feed mechanism are driven by gears made from hardened alloy

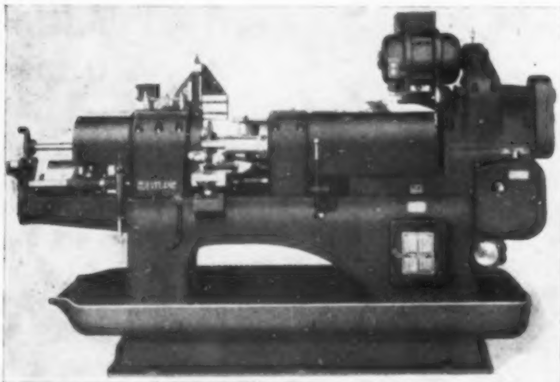

Fig. 19.

steel. Spindle change-gears are provided to cover a range of speeds consistent with the highest-speed cutting tools. Both drive shafts carrying the spindle change-gears extend through the bearings of the drive bracket, permitting rapid change. Spindles are made from alloy steel forgings. Bronze bearings, keyed to the spindles, run in high-carbon steel sleeves, which are hardened, ground, and lapped to size, and keyed to the spindle turret.

The spindle end thrust is carried on ball thrust bearings. Tapered front bearings and straight rear bearings provide an adjustment accomplished by taking-up nuts at the rear end of the spindle bearings, ensuring positive alignment between work spindles and turret tools.

The machine has two camshafts made from alloy steel and provided with large keyways. The upper camshaft carries the wormwheel, combination reaming and threading drum, turret and cross-slide drums, as well as the disc and cam to operate the top slide. On the lower camshaft are the gauge stop disc, indexing arm, chuck, and stock feed drums. Both camshafts are up out of the oil and free from chip interference, enabling the operator to make all cam adjustments with ease.

The square turret attachment affords four extra tool positions for end-cutting tools, which are independent of the tools carried on the main tool turret.

The threading spindle operates independently of the tool turret and is driven by cluster gears which provide a 1-to-4 and 1-to-5 ratio to the spindle speed. An instantaneous trip mechanism is mounted over the threading drive and controlled from the threading spindle, which is arranged for either right- or left-hand threading.

The tool feed is designed to cover a wide range of cutting feeds, eliminating the necessity of special cams. The gears are arranged for a geometrical progression of feeds, consistent for the variations in metals to be machined. The feed per spindle revolution remains constant and not affected by changes in spindle speeds.

A control lever, conveniently located, enables the operator to stop or start the feed in any position of the cut. The upper wormshaft extends through the gearbox and provides for the attaching of a crank to turn the machine over by hand when setting up. Gravity feed lubrication to all spindle-head bearings is provided by a reservoir mounted on the spindle turret cap. Brass tubes connect the reservoir to sight-feed oilers controlling the flow to each bearing. Oil supply to tools is direct by pump. The machine can be arranged for either belt or notor drive, using A.C. or D.C. constant-speed motors.